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Roadkill records of reptiles and birds in Cerrado and Pantanal landscapes

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Abstract
We monitored reptile and bird roadkills in Cerrado–Pantanal landscapes along the Campo Grande to Corumbá highway BR-262. We describe species distribution in different landscape zones, including the first geographic record for *Hydrodynastes bicinctus* Herrmann, 1804 in the Pantanal basin. The roadkill occurrence of *Spizaetus melanoleucus* (Vieillot, 1816) is an outstanding record. We recorded 930 individuals belonging to 29 reptile and 47 bird species; 20 of these species are new roadkill records in Brazil. The 8 new records of reptile species include *Eunectes notaeus* Cope, 1862, *Bothrops mattogrossensis* Amaral,1925, *Dracaena paraguayensis* Amaral,1950 and *H. bicinctus*; and 12 new records of bird species include *S. melanoleucus, Heterospizias meridionalis* Latham, 1790, *Urubitinga urubitinga* (Gmelin, 1788), *Pulsatrix perspicillata* (Latham, 1790), *Aramus guarauna* (Linnaeus, 1766), and *Jabiru mycteria* (Lichtenstein, 1819). Richness of road-killed species on the BR-262 highway seemed to be high, reinforcing concerns about wildlife-vehicle collisions where these accidents occur, as they lead to long term and chronic impacts on wildlife and road safety in the Pantanal region.

Key words
Geographic distribution; *Hydrodynastes bicinctus*; *Spizaetus melanoleucus*; Mato Grosso do Sul; road ecology; upper Paraguay basin; wildlife-vehicle collisions.

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Introduction

Regarding road ecology, results from road-killed fauna surveys have been useful for recording vertebrate species occurrences and updating geographic distributions of species within different landscapes (Olson et al. 2014). Although wildlife-vehicle collisions have negative impacts, roadkills have been used to sample fauna throughout the world (Forman et al. 2003). Oftentimes, this situation is tragic for several wildlife groups, particularly when such routes cross natural and poorly protected areas with rich and abundant fauna, as the Brazilian Cerrado and Pantanal (Catella et al. 2010). One such road is the federal highway BR-262, especially the 450 km between the cities of Campo Grande and Corumbá in Mato Grosso do Sul, Brazil (Fischer 1997, Casella 2010, De Souza et al. 2014).

Recent efforts have been made to update fauna checklists in Mato Grosso do Sul, where most records are con-

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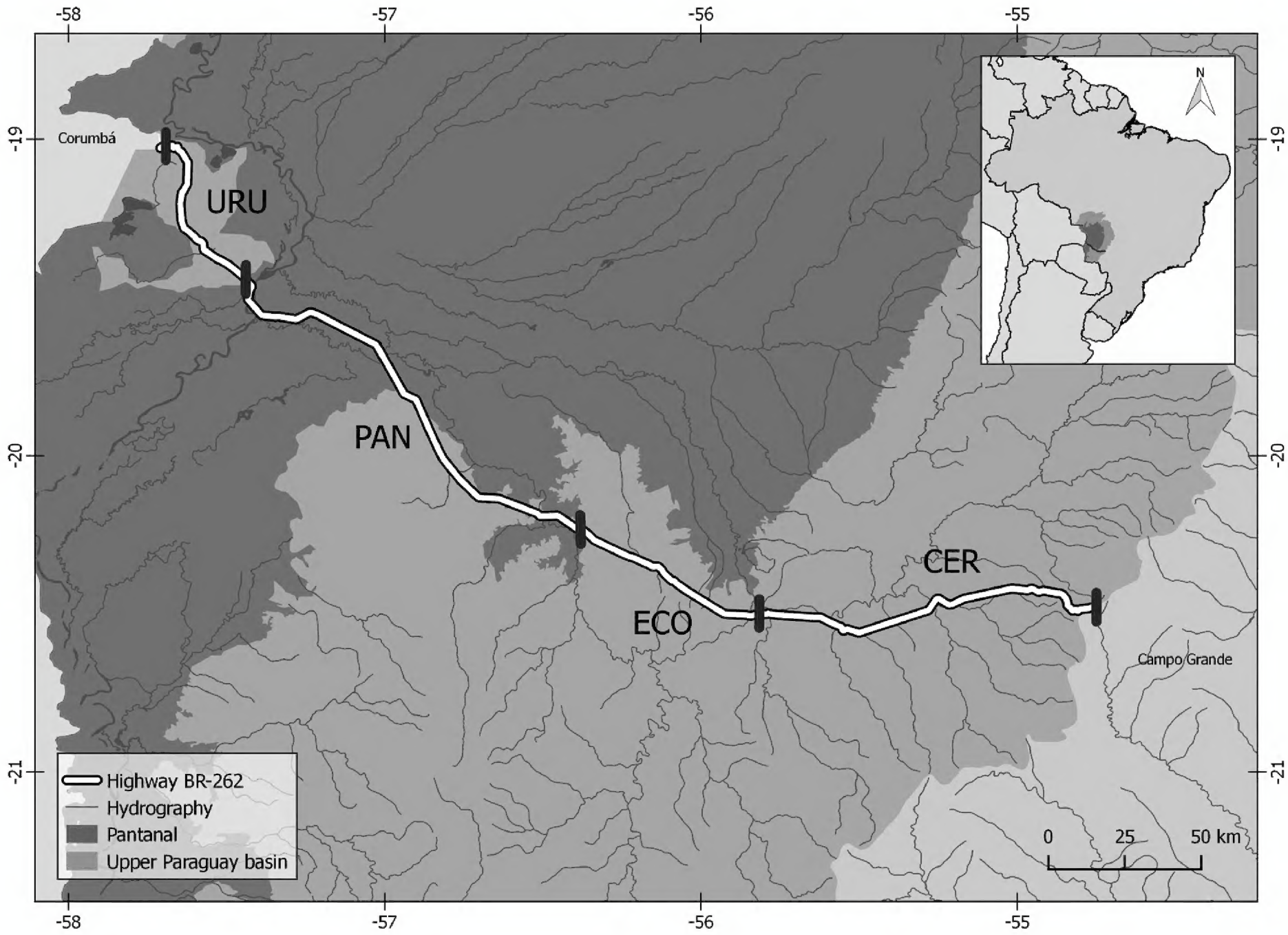

Figure 1. The regions of Cerrado and Pantanal crossed by the highway BR-262 in Mato Grosso do Sul, and the 4 zones studied here. CER = Cerrado plateau. ECO = Cerrado-Pantanal ecotone. PAN = Pantanal floodplain. URU = Urucum residual plateau.

centrated in particular geographic regions (Cáceres et al. 2008, Fischer et al. 2015, Ferreira et al. 2017, Nunes et al. 2017, Tomas et al. 2017). Large scale spatiotemporal monitoring of regional fauna has provided information about species distribution within different environments, as well as for the Cerrado and Pantanal domains (e.g. Alho et al. 2011, Braz and França 2016, Saranholi et al. 2016). The long-term project called Programa Estrada Viva: BR-262 monitored the road-killed fauna along the highway between Campo Grande and Corumbá, providing a broad database for wildlife management (Fischer 1997, GEIPOT 1999). Seeing as the road is a transect for trapping fauna with vehicles, this 450 km long segment of the BR-262 allowed a broad spectrum of regional wildlife to be surveyed (Fischer 1997). The roadway includes relevant ecological regions and cuts through rural zones and natural ecosystems, including the huge Pantanal floodplain and its interface with the Cerrado and forest remnants (Catella et al. 2010). Generally, road-killed mammals often involve large animals that cause serious accidents, being the first to catch public attention and concerns about road safety, making highway mortality of other groups, such as reptiles and birds, relatively less reported (e.g. Casella 2010, Ascensão et al. 2017). Herein, we describe the occurrence of reptiles and birds in the Cerrado–Pantanal landscapes along the highway BR-262 and update the regional geographic distribution of some species.

Methods

The present study was conducted along the paved 2-lane federal highway BR-262 between Campo Grande and Corumbá, Mato Grosso do Sul, Brazil (Fig. 1). This stretch of road crosses the Brazilian Pantanal, a large tropical wetland, which has low human population density and its main economic activities is extensive livestock (Assine 2015). The landscape along this highway presents a gradient of savannah environments between Cerrado and Pantanal in the upper Paraguay river basin.

We classified road segments into 4 zones according to the environment types along the Cerrado and Pantanal domains as follows: (i) Cerrado plateau (CER): 130 km of Cerrado landscapes from the Campo Grande plateau to the Anastácio/Aquidauana municipalities. (ii) Cerrado-Pantanal ecotone (ECO): 70 km of high and low elevations from the Cerrado plateau to the eastern border of the Pantanal floodplain at Miranda municipality. (iii) Pantanal floodplain (PAN): 150 km through the Pantanal. (iv) Urucum residual plateau (URU): 60 km of isolated hills on the Pantanal's western border, where the urban centers of Corumbá and Ladário municipalities are located (Fig. 1).

We used the species checklist of reptiles and birds from a database recorded between 1996 and 2000. This database contained vertebrate roadkill data from all road

sections (410 km in total) that were recorded monthly using vehicles at slow speeds (60 km/h), which traveled in both directions on the road (round trip) during a period of 43 months in the CER, ECO, and PAN zones, and 36 months in the URU zone (Table 1). The total sample effort was 29,740 km. Collection activities were carried out with official permit IBAMA-MS 01385/96. Every individual reptile or bird occurrence on both the lanes and roadsides of the BR-262 was recorded (geospatial data), identified in the field, and removed from the road or roadside. In the field, most individuals were identified to species, and intact carcasses were collected and deposited into the zoological collection at the Universidade Federal de Mato Grosso do Sul (ZUFMS). When species identifi-

Table 1. Number of trips for roadkill surveys on the highway BR-262 in for zones across the Cerrado and Pantanal landscapes. CER = Cerrado plateau. ECO = Cerrado-Pantanal ecotone. PAN = Pantanal floodplain. URU = Urucum residual plateau.

Date	Campaign (#)	CER (130 km)	ECO (70 km)	PAN (150 km)	URU (60 km)	Sample effort (km·month^{-1})
April 1996	1	1	1	1		350
May 1996	2	2	2	2		700
June 1996	3	1	1	1		350
July 1996	4	2	2	2		700
August 1996	5	2	2	1		550
September 1996	6	2	2	2		700
October 1996	7	2	2	2		700
November 1996	8	2	2	2	2	820
February 1997	9	3	3	2	2	1020
March 1997	10	4	4	3	2	1370
April 1997	11	2	2	2	2	820
May 1997	12	2	2	2	1	760
June 1997	13	2	2	2	2	820
July 1997	14	2	2	2	2	820
August 1997	15	2	2	1	1	610
September 1997	16	2	2	1	1	610
October 1997	17	2	2	2	1	760
November 1997	18	2	2	2	2	820
December 1997	19	1	1	1	1	410
January 1998	20	2	2	2	2	820
February 1998	21	2	2	2	1	760
April 1998	22	2	2	1	1	610
May 1998	23	2	2	1	1	610
June 1998	24	2	2	1	1	610
July 1998	25	2	2	1	1	610
August 1998	26	1	1	1	1	410
September 1998	27	1	1	1	1	410
October 1998	28	2	2	2	2	820
November 1998	29	2	2	2	2	820
December 1998	30	2	2	2	2	820
January 1999	31	1	1	1	1	410
February 1999	32	2	2	2	2	820
March 1999	33	2	2	2	2	820
April 1999	34	2	2	1	1	610
May 1999	35	1	1	1	1	410
June 1999	36	1	1	2	2	620
July 1999	37	1	1	1	1	410
August 1999	38	2	2	2	2	820
September 1999	39	2	2	2	2	820
December 1999	40	2	2	2	2	820
January-00	41	2	2	2	2	820
February-00	42	2	2	1	1	610
March-00	43	2	2	2	1	760
Total distance (km)		**10.400**	**5.600**	**10.500**	**3.240**	**29.740**
Total trips (*n*)		**80**	**80**	**70**	**54**	
Total campaigns (months)		**43**	**43**	**43**	**36**	

cation was not possible in the field, we collected carcasses for further measurements and taxonomic characters in the laboratory or photographed the corpse's remains. Identifications were confirmed by consulting specialists, field books and guides (e.g. Norman and Naylor 1994, Sick 1997, Souza and Borges 1998, Gwynne et al. 2008, Bernarde 2012, Sigrist 2014), the ZUFMS collection (https://inbio.ufms.br/zufms/acervo-online), and taxonomic databases, including SiBBr (http://www.sibbr.gov.br/), PortalBio (http://portaldabiodiversidade.icmbio.gov.br/portal/), IUCN Red List of Threatened Species (http://www.iucnredlist.org/), Encyclopedia of Life (http://www.eol.org), Integrated Taxonomic Information System (http://www.itis.gov), The Reptile Database (http://www.reptile-database.org), Aves de Rapina do Brasil (http://www.avesderapinabrasil.com), Avibase (http://avibase.bsc-eoc.org), Neotropical Birds Online (http://neotropical.birds.cornell.edu), WikiAves (http://www.wikiaves.com) and Wildscreen Arkive (http://www.arkive.org). Worthless specimen remains were discarded after species identification. We summarize the taxonomic features used for species identification procedures. In the tables, we present species information with the geospatial data of each individual. We adopt the taxonomic nomenclature from The Reptile Database (Uetz 2018) for reptile species, and from the Brazilian Ornithological Records Committee (CBRO) for birds (Piacentini et al. 2015). To obtain comparable data from the 4 zones, we standardized the number of road-killed individuals using the respective sample effort and the road extension (km) crossing each zone, hereafter labeled relative abundance. We used rarefaction curves based on the cumulative quantity of captured individuals and Chao 1 index (100 randomizations) with help of ESTIMATES 9.1 (Colwell 2013) to estimate the expected richness in each landscape zone.

First geographic records (FGR) and new roadkill records (NRR) for reptile and bird species were verified from the literature. We compared our dataset to data collected by De Souza et al. (2014) from the same highway (BR-262) and data of road-killed reptiles and birds from other Brazilian roads (Novelli et al. 1988, Prado et al. 2006, Silva et al. 2007, Coelho et al. 2008, Hengemühle and Cademartori 2008, Cunha et al. 2010, Hartmann et al. 2011, Ramos et al. 2011, Santana 2012, Santos et al. 2012, 2014 Carvalho et al. 2014, Carvalho et al. 2015, Cunha et al. 2015, Klippel et al. 2015, Machado et al. 2015, Almeida et al. 2016, Braz and França 2016, Deffaci et al. 2016, Saranholi et al 2016, Steil et al. 2016, Corrêa et al. 2017, Miranda et al. 2017, Rodríguez-Castro et al. 2017, Viturino and Graciolli 2017, Gonçalves et al. 2018, Ramos-Abrantes et al. 2018).

Results

We recorded 930 road-killed individuals, 414 reptiles of 29 species from 10 families, 3 orders (18 unidentified lizards and snakes) and 516 birds of 47 species from 26 families and 18 orders (64 unidentified specimens) (Tables 2, 3).

Table 2. Reptile roadkill species from the Cerrado and Pantanal landscapes on the highway BR-262. CER = Cerrado plateau. ECO = Cerrado--Pantanal ecotone. PAN = Pantanal floodplain. URU = Urucum residual plateau. *N* = Number of individuals. + = Alien species. [FGR] = First geographic record. [NRR] New roadkill record.

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
TESTUDINES												
Chelidae												
Phrynops geoffroanus (Schweigger, 1812)	2	-20.42	-54.99	1	-20.45	-56.00						
		-20.51	-55.64									
Emydidae												
Trachemys scripta (Schoepff, 1792) + [NRR]				1	-20.42	-56.05						
CROCODYLIA												
Alligatoridae												
Caiman yacare (Daudin, 1801)	11	-20.42	-55.04	17	-20.50	-55.89	148	-20.20	-56.44	11	-19.37	-57.54
		-20.43	-55.06		-20.50	-55.90		-20.20	-56.44		-19.35	-57.57
		-20.49	-55.28		-20.48	-55.96		-20.19	-56.48		-19.32	-57.58
		-20.55	-55.52		-20.48	-55.97		-20.19	-56.48		-19.32	-57.58
		-20.55	-55.53		-20.46	-55.98		-20.19	-56.48		-19.32	-57.59
		-20.52	-55.60		-20.46	-55.98		-20.19	-56.49		-19.32	-57.59
		-20.52	-55.61		-20.46	-55.99		-20.19	-56.50		-19.31	-57.60
		-20.51	-55.63		-20.45	-56.00		-20.18	-56.52		-19.31	-57.60
		-20.51	-55.69		-20.44	-56.02		-20.18	-56.52		-19.30	-57.61
		-20.50	-55.79		-20.44	-56.03		-20.18	-56.53		-19.29	-57.63
		-20.50	-55.79		-20.41	-56.06		-20.17	-56.54		-19.25	-57.64
					-20.41	-56.07		-20.17	-56.56			
					-20.41	-56.07		-20.16	-56.57			
					-20.41	-56.07		-20.16	-56.57			
					-20.36	-56.12		-20.16	-56.58			
					-20.36	-56.12		-20.16	-56.58			
					-20.30	-56.27		-20.15	-56.60			
					-20.50	-55.90		-20.15	-56.60			
								-20.15	-56.61			
								-20.14	-56.63			
								-20.14	-56.63			

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
								-20.13	-56.67			
								-20.13	-56.68			
								-20.13	-56.70			
								-20.13	-56.70			
								-20.13	-56.71			
								-20.12	-56.72			
								-20.11	-56.72			
								-20.11	-56.73			
								-20.11	-56.73			
								-20.10	-56.73			
								-20.09	-56.74			
								-20.09	-56.75			
								-20.08	-56.76			
								-20.07	-56.76			
								-20.06	-56.78			
								-20.06	-56.78			
								-20.05	-56.78			
								-20.05	-56.78			
								-20.03	-56.80			
								-20.03	-56.80			
								-20.01	-56.81			
								-20.00	-56.82			
								-20.00	-56.82			
								-20.00	-56.82			
								-20.00	-56.82			
								-20.00	-56.82			
								-19.98	-56.83			
								-19.98	-56.83			
								-19.97	-56.84			
								-19.97	-56.84			
								-19.97	-56.84			
								-19.96	-56.84			
								-19.91	-56.86			
								-19.90	-56.86			
								-19.90	-56.87			
								-19.89	-56.87			
								-19.87	-56.88			
								-19.87	-56.88			
								-19.85	-56.89			
								-19.84	-56.89			
								-19.84	-56.89			
								-19.84	-56.89			
								-19.82	-56.90			
								-19.82	-56.91			
								-19.81	-56.93			
								-19.81	-56.93			
								-19.81	-56.93			
								-19.79	-56.95			
								-19.78	-56.95			
								-19.78	-56.95			
								-19.78	-56.95			
								-19.76	-56.96			
								-19.76	-56.97			
								-19.75	-56.97			
								-19.74	-56.98			
								-19.74	-56.98			
								-19.74	-56.98			
								-19.73	-56.98			
								-19.73	-56.98			
								-19.72	-56.99			
								-19.71	-56.99			
								-19.70	-57.00			
								-19.70	-57.00			
								-19.70	-57.00			
								-19.69	-57.00			
								-19.68	-57.01			
								-19.68	-57.01			
								-19.68	-57.01			
								-19.68	-57.01			
								-19.68	-57.01			
								-19.67	-57.02			
								-19.66	-57.02			

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
								-19.65	-57.03			
								-19.65	-57.03			
								-19.65	-57.03			
								-19.64	-57.04			
								-19.64	-57.04			
								-19.61	-57.11			
								-19.61	-57.11			
								-19.60	-57.12			
								-19.60	-57.12			
								-19.60	-57.12			
								-19.59	-57.13			
								-19.59	-57.14			
								-19.59	-57.14			
								-19.58	-57.17			
								-19.57	-57.18			
								-19.55	-57.21			
								-19.55	-57.22			
								-19.55	-57.22			
								-19.55	-57.22			
								-19.55	-57.22			
								-19.55	-57.22			
								-19.55	-57.23			
								-19.55	-57.23			
								-19.55	-57.25			
								-19.55	-57.25			
								-19.55	-57.25			
								-19.56	-57.25			
								-19.56	-57.26			
								-19.56	-57.27			
								-19.57	-57.27			
								-19.57	-57.28			
								-19.57	-57.29			
								-19.57	-57.29			
								-19.57	-57.29			
								-19.57	-57.30			
								-19.57	-57.30			
								-19.57	-57.30			
								-19.56	-57.31			
								-19.56	-57.31			
								-19.56	-57.31			
								-19.56	-57.31			
								-19.56	-57.31			
								-19.56	-57.32			
								-19.56	-57.32			
								-19.56	-57.32			
								-19.56	-57.33			
								-19.56	-57.33			
								-19.56	-57.34			
								-19.56	-57.34			
								-19.56	-57.35			
								-19.56	-57.35			
								-19.55	-57.39			
								-19.49	-57.43			
								-19.47	-57.42			
								-19.44	-57.44			
SQUAMATA-LACERTILIA												
Iguanidae												
Iguana iguana (Linnaeus, 1758)							3	-20.21	-56.42			
								-19.64	-57.04			
								-19.55	-57.21			
Teiidae												
Ameiva ameiva (Linnaeus, 1758)	1	-20.45	-55.25	2	-20.47	-55.97	3	-20.19	-56.45	2	-19.33	-57.57
					-20.28	-56.31		-20.06	-56.78		-19.30	-57.61
								-19.57	-57.28			
Dracaena paraguayensis Amaral, 1950 [NRR]							3	-20.19	-56.48	1	-19.29	-57.63
								-20.19	-56.50			
								-19.56	-57.36			
Salvator merianae (Duméril & Bibron, 1839)	20	-20.43	-54.97	2	-20.30	-56.27	20	-20.23	-56.39	2	-19.29	-57.62
		-20.42	-54.97		-20.28	-56.31		-20.19	-56.45		-19.14	-57.62
		-20.42	-54.99					-20.18	-56.53			
		-20.42	-54.99					-20.16	-56.58			
		-20.43	-55.09					-20.15	-56.59			

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
		-20.44	-55.10					-20.15	-56.60			
		-20.46	-55.23					-20.15	-56.61			
		-20.45	-55.25					-20.15	-56.61			
		-20.56	-55.51					-20.14	-56.63			
		-20.54	-55.57					-20.13	-56.69			
		-20.53	-55.58					-20.05	-56.78			
		-20.53	-55.59					-20.05	-56.78			
		-20.51	-55.62					-20.03	-56.80			
		-20.51	-55.62					-20.01	-56.82			
		-20.51	-55.63					-19.98	-56.83			
		-20.51	-55.63					-19.85	-56.89			
		-20.51	-55.64					-19.65	-57.03			
		-20.51	-55.64					-19.63	-57.07			
		-20.51	-55.64					-19.61	-57.10			
		-20.51	-55.68					-19.57	-57.18			
Unknown	1	73.6	-20.49				3	-20.15	-56.60			
								-19.78	-56.95			
								-19.76	-56.96			
SQUAMATA-SERPENTES												
Boidae												
Boa constrictor Linnaeus, 1758	3	-20.45	-55.18	1	-20.44	-56.03	1	-20.02	-56.81	2	-19.30	-57.61
		-20.51	-55.63								-19.18	-57.64
		-20.50	-55.74									
Eunectes murinus (Linnaeus, 1758)	1	-20.43	-55.06									
Eunectes notaeus Cope, 1862 [NRR]	3	-20.43	-54.87				78	-20.19	-56.51	2	-19.31	-57.60
		-20.42	-55.03					-20.19	-56.51		-19.08	-57.62
		-20.47	-55.22					-20.16	-56.59			
								-20.14	-56.62			
								-20.13	-56.70			
								-20.13	-56.71			
								-19.89	-56.87			
								-19.73	-56.98			
								-19.68	-57.01			
								-19.65	-57.03			
								-19.64	-57.04			
								-19.64	-57.05			
								-19.63	-57.07			
								-19.62	-57.08			
								-19.61	-57.11			
								-19.60	-57.11			
								-19.60	-57.11			
								-19.58	-57.15			
								-19.58	-57.15			
								-19.58	-57.16			
								-19.58	-57.16			
								-19.58	-57.16			
								-19.58	-57.17			
								-19.57	-57.17			
								-19.57	-57.18			
								-19.57	-57.19			
								-19.57	-57.19			
								-19.57	-57.19			
								-19.57	-57.19			
								-19.56	-57.19			
								-19.56	-57.21			
								-19.55	-57.21			
								-19.55	-57.22			
								-19.55	-57.22			
								-19.55	-57.22			
								-19.55	-57.23			
								-19.55	-57.23			
								-19.55	-57.24			
								-19.55	-57.24			
								-19.55	-57.24			
								-19.55	-57.24			
								-19.55	-57.24			
								-19.55	-57.24			
								-19.55	-57.24			
								-19.55	-57.25			
								-19.55	-57.25			

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
								-19.56	-57.25			
								-19.56	-57.26			
								-19.56	-57.26			
								-19.56	-57.26			
								-19.56	-57.27			
								-19.56	-57.27			
								-19.56	-57.27			
								-19.57	-57.27			
								-19.57	-57.28			
								-19.57	-57.29			
								-19.56	-57.19			
								-19.57	-57.27			
								-19.57	-57.30			
								-19.57	-57.30			
								-19.56	-57.31			
								-19.56	-57.31			
								-19.56	-57.32			
								-19.56	-57.32			
								-19.56	-57.32			
								-19.56	-57.33			
								-19.56	-57.33			
								-19.56	-57.34			
								-19.56	-57.35			
								-19.56	-57.35			
								-19.56	-57.35			
								-19.56	-57.37			
								-19.54	-57.41			
								-19.51	-57.43			
								-19.50	-57.43			
								-19.47	-57.42			
Colubridae												
Chironius quadricarinatus (Boie, 1827)				1	-20.50	-55.85	4	-20.22	-56.41	1	-19.10	-57.62
								-19.79	-56.95			
								-19.69	-57.00			
								-19.55	-57.25			
Drymarchon corais (Boie, 1827)				1	-20.28	-56.31						
Mastigodryas bifossatus (Raddi, 1820)				4	-20.44	-56.03	2	-20.21	-56.43	3	-19.39	-57.51
					-20.41	-56.07		-20.13	-56.71		-19.32	-57.58
					-20.34	-56.17					-19.11	-57.62
					-20.31	-56.25						
Spilotes pullatus (Linnaeus, 1758)	1	-20.50	-55.75	2	-20.50	-55.91						
					-20.50	-55.93						
Dipsadidae												
Erythrolamprus aesculapii (Linnaeus, 1758)	2	-20.42	-54.99									
		-20.44	-55.12									
Erythrolamprus poecilogyrus (Wied, 1825)							1	-19.59	-57.15			
Helicops leopardinus (Schlegel, 1837) [NRR]							2	-19.65	-57.03			
								-19.55	-57.22			
Hydrodynastes bicinctus (Herrmann, 1804) [FGR, NRR]							1	-19.67	-57.01			
Hydrodynastes gigas (Duméril et al.,1854)							7	-20.21	-56.43			
								-20.05	-56.78			
								-20.02	-56.81			
								-19.79	-56.95			
								-19.68	-57.01			
								-19.56	-57.21			
								-19.48	-57.43			
Mussurana bicolor (Peracca, 1904) [NRR]							1	-19.56	-57.35			
Philodryas mattogrossensis Koslowsky, 1898	1	-20.42	-55.04				1	-20.02	-56.81			
Philodryas olfersii (Lichtenstein, 1823)	1	-20.44	-55.12	2	-20.36	-56.12	1	-19.76	-56.96	2	-19.23	-57.64
					-20.34	-56.17					-19.17	-57.64
Thamnodynastes hypoconia (Cope, 1860)							1	-19.64	-57.05			
Xenodon matogrossensis (Scrocchi & Cruz, 1993)	2	-20.42	-54.94									
		-20.45	-55.17									
Xenodon merremii (Wagler in Spix, 1824)	2	-20.45	-54.85							1	-19.14	-57.63
		-20.55	-55.55									
Typhlopidae												
Amerotyphlops brongersmianus Vanzolini, 1976 [NRR]	1	-20.42	-54.97									
Viperidae												
Bothrops mattogrossensis Amaral, 1925 [NRR]							1	-19.63	-57.06	1	-19.08	-57.62
Bothrops moojeni Hoge, 1966	1	-20.45	-55.15	1	-20.50	-55.83	1	-19.99	-56.83	1	-19.32	-57.58
Crotalus durissus (Laurenti, 1768)										1	-19.16	-57.63
Unknown	2	-20.55	-55.55	1	-20.37	-56.12	8	-20.17	-56.55	3	-19.42	-57.47

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
		-20.51	-55.68					-20.17	-56.56		-19.37	-57.55
								-20.17	-56.56		-19.19	-57.64
								-19.77	-56.96			
								-19.66	-57.02			
								-19.56	-57.21			
								-19.57	-57.27			
								-19.56	-57.35			
SUMMARY												
Sampled individuals (n)	**55**			**36**			**290**			**33**		
Relative abundance (%)	**9.7**			**11.8**			**58.6**			**19.8**		
Observed richness (n)	**15**			**12**			**19**			**13**		
Chao 1 (95% CI)	**23 (16-57)**			**25 (21-45)**			**27 (23-46)**			**27 (25-45)**		

Table 3.. Bird roadkill species from the Cerrado and Pantanal landscapes on the highway BR-262. CER = Cerrado plateau. ECO = Cerrado–Pantanal ecotone. PAN = Pantanal floodplain. URU = Urucum residual plateau. *N* = Number of individuals. [NRR] = New roadkill record.

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
STRUTHIONIFORMES												
Rheidae												
Rhea americana (Linnaeus, 1758)	1	-20.50	-55.31				1	-19.80	-56.94	1	-19.33	-57.57
TINAMIFORMES												
Tinamidae												
Crypturellus parvirostris (Wagler, 1827)				1	-20.29	-56.29						
Nothura maculosa (Temminck, 1815)	1	-20.45	-55.25	1	-20.35	-56.16	2	-20.20	-56.43			
								-20.13	-56.70			
Rhynchotus rufescens (Temminck, 1815)	1	-20.54	-55.45									
GALLIFORMES												
Cracidae												
Penelope superciliaris Temminck, 1815							1	-19.77	-56.96	1	-19.33	-57.57
CICONIIFORMES												
Ciconiidae												
Jabiru mycteria (Lichtenstein, 1819) [NRR]							1	-19.58	-57.17			
CATHARTIFORMES												
Cathartidae												
Cathartes aura (Linnaeus, 1758)							1	-19.56	-57.33	2	-19.38	-57.52
											-19.38	-57.53
Cathartes burrovianus Cassin, 1845							1	-19.59	-57.15			
Coragyps atratus (Bechstein, 1793)	7	-20.45	-54.69	16	-20.50	-55.87	79	-20.21	-56.43	14	-19.42	-57.46
		-20.47	-55.20		-20.50	-55.90		-20.19	-56.46		-19.42	-57.47
		-20.45	-55.25		-20.48	-55.97		-20.19	-56.47		-19.41	-57.47
		-20.51	-55.34		-20.41	-56.00		-20.19	-56.49		-19.41	-57.47
		-20.53	-55.41		-20.44	-56.02		-20.19	-56.51		-19.40	-57.48
		-20.54	-55.44		-20.40	-56.09		-20.17	-56.55		-19.37	-57.54
		-20.54	-55.44		-20.39	-56.10		-20.16	-56.57		-19.35	-57.57
					-20.38	-56.10		-20.16	-56.58		-19.34	-57.57
					-20.38	-56.10		-20.16	-56.58		-19.30	-57.61
					-20.38	-56.11		-20.16	-56.59		-19.29	-57.62
					-20.29	-56.29		-20.15	-56.60		-19.27	-57.64
					-20.29	-56.29		-20.15	-56.60		-19.26	-57.64
					-20.29	-56.30		-20.15	-56.60		-19.25	-57.64
					-20.28	-56.31		-20.15	-56.60		-19.20	-57.65
					-20.27	-56.33		-20.15	-56.61			
					-20.25	-56.36		-20.14	-56.63			
								-20.14	-56.64			
								-20.13	-56.66			
								-20.13	-56.68			
								-20.13	-56.68			
								-20.13	-56.70			
								-20.13	-56.70			
								-20.13	-56.70			
								-20.13	-56.71			
								-20.12	-56.71			
								-20.11	-56.72			
								-20.10	-56.74			
								-20.09	-56.74			
								-20.09	-56.74			
								-20.08	-56.75			
								-20.07	-56.77			

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
								-20.02	-56.80			
								-20.02	-56.81			
								-20.02	-56.81			
								-20.00	-56.82			
								-20.00	-56.82			
								-19.99	-56.83			
								-19.97	-56.84			
								-19.96	-56.84			
								-19.94	-56.85			
								-19.90	-56.86			
								-19.88	-56.87			
								-19.87	-56.88			
								-19.84	-56.89			
								-19.84	-56.89			
								-19.82	-56.91			
								-19.82	-56.92			
								-19.80	-56.94			
								-19.77	-56.96			
								-19.76	-56.97			
								-19.65	-57.02			
								-19.65	-57.03			
								-19.65	-57.03			
								-19.64	-57.05			
								-19.63	-57.06			
								-19.61	-57.11			
								-19.60	-57.12			
								-19.60	-57.12			
								-19.59	-57.13			
								-19.58	-57.15			
								-19.58	-57.16			
								-19.56	-57.20			
								-19.56	-57.20			
								-19.56	-57.21			
								-19.56	-57.21			
								-19.55	-57.22			
								-19.55	-57.24			
								-19.55	-57.25			
								-19.55	-57.25			
								-19.55	-57.25			
								-19.56	-57.26			
								-19.56	-57.32			
								-19.56	-57.33			
								-19.56	-57.39			
								-19.56	-57.39			
								-19.51	-57.43			
								-19.47	-57.42			
								-19.46	-57.43			
								-19.44	-57.44			
ACCIPITRIFORMES												
Accipitridae												
Heterospizias meridionalis Latham, 1790 [NRR]	3	-20.54	-55.44									
		-20.50	-55.76									
		-20.50	-55.78									
Rostrhamus sociabilis (Vieillot, 1817)							2	-19.81	-56.92			
								-19.49	-57.43			
Rupornis magnirostris (Gmelin, 1788)	2	-20.46	-54.84	1	-20.35	-56.14						
		-20.42	-55.00									
Spizaetus melanoleucus (Vieillot, 1816) [NRR]							1	-19.64	-57.05			
Urubitinga urubitinga (Gmelin, 1788) [NRR]							1	-19.62	-57.09			
FALCONIFORMES												
Falconidae												
Caracara plancus (Miller, 1777)	8	-20.42	-54.98	25	-20.50	-55.86	135	-20.22	-56.41	27	-19.43	-57.45
		-20.43	-55.06		-20.50	-55.88		-20.21	-56.43		-19.43	-57.45
		-20.45	-55.16		-20.50	-55.89		-20.20	-56.43		-19.43	-57.46
		-20.46	-55.20		-20.50	-55.89		-20.19	-56.45		-19.40	-57.49
		-20.50	-55.30		-20.50	-55.89		-20.19	-56.45		-19.39	-57.50
		-20.54	-55.45		-20.50	-55.90		-20.19	-56.46		-19.39	-57.51
		-20.55	-55.55		-20.49	-55.94		-20.19	-56.47		-19.38	-57.52
		-20.50	-55.77		-20.48	-55.96		-20.19	-56.48		-19.38	-57.52

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
					-20.47	-55.97		-20.19	-56.48		-19.36	-57.55
					-20.47	-55.97		-20.17	-56.55		-19.34	-57.57
					-20.45	-56.00		-20.16	-56.56		-19.34	-57.57
					-20.45	-56.01		-20.16	-56.56		-19.33	-57.57
					-20.44	-56.02		-20.16	-56.57		-19.33	-57.58
					-20.43	-56.03		-20.16	-56.57		-19.32	-57.58
					-20.43	-56.05		-20.16	-56.59		-19.32	-57.58
					-20.41	-56.07		-20.16	-56.59		-19.32	-57.58
					-20.40	-56.09		-20.16	-56.59		-19.32	-57.59
					-20.39	-56.09		-20.15	-56.60		-19.32	-57.59
					-20.36	-56.13		-20.15	-56.60		-19.31	-57.60
					-20.36	-56.13		-20.15	-56.60		-19.25	-57.64
					-20.35	-56.13		-20.15	-56.60		-19.24	-57.64
					-20.35	-56.14		-20.15	-56.60		-19.18	-57.64
					-20.30	-56.27		-20.15	-56.60		-19.17	-57.64
					-20.30	-56.27		-20.15	-56.61		-19.11	-57.62
					-20.27	-56.33		-20.14	-56.62		-19.10	-57.62
								-20.14	-56.62		-19.09	-57.62
								-20.14	-56.63		-19.07	-57.62
								-20.14	-56.65			
								-20.13	-56.66			
								-20.13	-56.69			
								-20.13	-56.69			
								-20.13	-56.70			
								-20.13	-56.70			
								-20.13	-56.70			
								-20.13	-56.71			
								-20.12	-56.72			
								-20.11	-56.73			
								-20.08	-56.76			
								-20.06	-56.77			
								-20.06	-56.78			
								-20.05	-56.78			
								-20.04	-56.79			
								-20.03	-56.80			
								-20.02	-56.81			
								-20.01	-56.81			
								-20.00	-56.82			
								-20.00	-56.82			
								-20.00	-56.82			
								-20.00	-56.82			
								-19.99	-56.83			
								-19.98	-56.83			
								-19.98	-56.83			
								-19.98	-56.83			
								-19.98	-56.83			
								-19.95	-56.84			
								-19.84	-56.89			
								-19.84	-56.89			
								-19.83	-56.90			
								-19.83	-56.90			
								-19.82	-56.90			
								-19.82	-56.90			
								-19.82	-56.91			
								-19.81	-56.92			
								-19.81	-56.93			
								-19.81	-56.93			
								-19.78	-56.95			
								-19.75	-56.97			
								-19.74	-56.97			
								-19.74	-56.97			
								-19.72	-56.99			
								-19.70	-57.00			
								-19.69	-57.01			
								-19.69	-57.01			
								-19.68	-57.01			
								-19.67	-57.01			
								-19.66	-57.02			
								-19.66	-57.02			

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
								-19.65	-57.03			
								-19.65	-57.03			
								-19.65	-57.03			
								-19.65	-57.03			
								-19.64	-57.04			
								-19.64	-57.04			
								-19.64	-57.05			
								-19.64	-57.05			
								-19.63	-57.06			
								-19.63	-57.07			
								-19.62	-57.08			
								-19.62	-57.08			
								-19.62	-57.09			
								-19.60	-57.12			
								-19.60	-57.12			
								-19.60	-57.12			
								-19.60	-57.12			
								-19.60	-57.13			
								-19.59	-57.15			
								-19.58	-57.16			
								-19.57	-57.18			
								-19.56	-57.20			
								-19.55	-57.21			
								-19.55	-57.21			
								-19.55	-57.22			
								-19.55	-57.22			
								-19.55	-57.23			
								-19.55	-57.23			
								-19.55	-57.23			
								-19.55	-57.23			
								-19.55	-57.23			
								-19.55	-57.25			
								-19.56	-57.26			
								-19.56	-57.26			
								-19.56	-57.27			
								-19.56	-57.32			
								-19.56	-57.32			
								-19.56	-57.32			
								-19.56	-57.32			
								-19.56	-57.33			
								-19.56	-57.34			
								-19.56	-57.35			
								-19.56	-57.37			
								-19.56	-57.38			
								-19.55	-57.39			
								-19.55	-57.40			
								-19.50	-57.43			
								-19.49	-57.43			
								-19.49	-57.43			
								-19.49	-57.43			
								-19.49	-57.43			
								-19.48	-57.43			
								-19.46	-57.42			
								-19.42	-57.43			
								-19.45	-57.43			
								-19.45	-57.43			
								-19.45	-57.43			
								-19.44	-57.44			
Falco sparverius Linnaeus, 1758	1	-20.45	-55.14									
GRUIFORMES												
Aramidae												
Aramus guarauna (Linnaeus, 1766) [NRR]							3	-19.68	-57.01			
								-19.63	-57.06			
								-19.56	-57.34			
Rallidae												
Aramides cajaneus (Statius Müller, 1776) [NRR]										2	-19.31	-57.60
											-19.25	-57.64

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
CARIAMIFORMES												
Cariamidae												
Cariama cristata (Linnaeus, 1766)	13	-20.42	-54.97	8	-20.48	-55.96	3	-20.15	-56.59	2	-19.40	-57.48
		-20.42	-54.97		-20.47	-55.97		-20.15	-56.60		-19.35	-57.57
		-20.43	-55.09		-20.40	-56.08		-20.13	-56.70			
		-20.44	-55.10		-20.34	-56.18						
		-20.44	-55.12		-20.34	-56.18						
		-20.47	-55.27		-20.33	-56.19						
		-20.50	-55.31		-20.31	-56.24						
		-20.50	-55.32		-20.30	-56.27						
		-20.54	-55.45									
		-20.55	-55.55									
		-20.55	-55.55									
		-20.54	-55.57									
		-20.50	-55.76									
CHARADRIIFORMES												
Jacanidae												
Jacana jacana (Linnaeus, 1766) [NRR]							1	-19.64	-57.04			
COLUMBIFORMES												
Columbidae												
Patagioenas picazuro (Temminck, 1813)							1	-20.13	-56.68			
Zenaida auriculata (Des Murs, 1847)				1	-20.50	-55.88						
PSITTACIFORMES												
Psittacidae												
Aratinga nenday (Vieillot, 1823) [NRR]							1	-19.93	-56.85	1	-19.32	-57.58
Eupsittula aurea (Gmelin, 1788)							4	-20.12	-56.72			
								-20.12	-56.72			
								-19.56	-57.31			
								-19.51	-57.43			
Forpus xanthopterygius (Spix, 1824) [NRR]							1	-19.56	-57.25			
CUCULIFORMES												
Cuculidae												
Crotophaga ani Linnaeus, 1758	7	-20.46	-54.71	1	-20.27	-56.33	3	-19.57	-57.17	4	-19.37	-57.54
		-20.47	-54.72					-19.57	-57.29		-19.35	-57.57
		-20.43	-54.90					-19.45	-57.43		-19.29	-57.63
		-20.42	-55.01								-19.13	-57.62
		-20.46	-55.23									
		-20.55	-55.46									
		-20.51	-55.71									
Guira guira (Gmelin, 1788)	6	-20.42	-54.99	2	-20.50	-55.85	3	-20.22	-56.40			
		-20.42	-54.99		-20.34	-56.18		-19.77	-56.96			
		-20.42	-55.04					-19.56	-57.36			
		-20.45	-55.14									
		-20.45	-55.25									
		-20.53	-55.59									
STRIGIFORMES												
Strigidae												
Asio clamator (Vieillot, 1808)	1	-20.42	-55.04	1	-20.43	-56.03	2	-20.21	-56.42			
								-19.71	-56.99			
Athene cunicularia (Molina, 1782)	1	-20.44	-55.09				1	-19.55	-57.25			
Bubo virginianus (Gmelin, 1788)	1	-20.46	-55.18				1	-19.56	-57.26			
Glaucidium brasilianum (Gmelin, 1788)	2	-20.44	-55.11									
		-20.51	-55.72									
Pulsatrix perspicillata (Latham, 1790) [NRR]				1	-20.33	-56.19						
Tytonidae												
Tyto furcata (Temminck, 1827)	1	-20.47	-55.22									
CAPRIMULGIFORMES												
Caprimulgidae												
Hydropsalis torquata (Gmelin, 1789)							1	-19.64	-57.05			
Nyctidromus albicollis (Gmelin, 1789)	2	-20.43	-55.08									
		-20.50	-55.79									
CORACIIFORMES												
Alcedinidae												
Chloroceryle americana (Gmelin, 1788) [NRR]							1	-19.57	-57.18			
PICIFORMES												
Ramphastidae												
Ramphastos toco Statius Müller, 1776	1	-20.47	-55.27	1	-20.30	-56.27	1	-19.82	-56.90			
Picidae												
Colaptes campestris (Vieillot, 1818)	1	-20.44	-55.11				1	-19.57	-57.28			

Taxon	CER			ECO			PAN			URU		
	N	Lat	Long	*N*	Lat	Long	*N*	Lat	Long	*N*	Lat	Long
PASSERIFORMES												
Emberizidae												
Paroaria capitata (d'Orbigny &Lafresnaye, 1837)							5	-19.77	-56.96			
								-19.72	-56.98			
								-19.64	-57.05			
								-19.56	-57.19			
								-19.56	-57.26			
Furnariidae												
Furnarius rufus (Gmelin, 1788)							1	-19.56	-57.35			
Hirundinidae												
Pygochelidon cyanoleuca (Vieillot, 1817)							2	-19.57	-57.29	1	-19.29	-57.63
								-19.56	-57.38			
Icteridae												
Gnorimopsar chopi (Vieillot, 1819)	2	-20.47	-54.74	1	-20.50	-55.82	6	-20.23	-56.39	1	-19.11	-57.62
		-20.44	-54.86					-20.17	-56.55			
								-19.63	-57.07			
								-19.61	-57.10			
								-19.55	-57.22			
								-19.47	-57.42			
Icterus croconotus (Wagler, 1829) [NRR]										1	-19.06	-57.62
Turdidae												
Turdus amaurochalinus Cabanis, 1850	1	-20.42	-55.03									
Turdus rufiventris Vieillot, 1818							1	-20.18	-56.52			
Tyrannidae												
Pitangus sulphuratus (Linnaeus, 1766)	1	-20.51	-55.36									
Tyrannus savana Daudin, 1802	1	-20.51	-55.70				2	-19.58	-57.16			
								-19.56	-57.39			
Unknown	23	-20.49	-54.80	11	-20.50	-55.90	27	-20.23	-56.39	3	-19.33	-57.57
		-20.46	-54.84		-20.46	-55.99		-20.23	-56.40		-19.29	-57.62
		-20.44	-54.86		-20.42	-56.06		-20.21	-56.42		-19.23	-57.64
		-20.44	-54.86		-20.40	-56.08		-20.19	-56.49			
		-20.43	-54.88		-20.38	-56.11		-20.15	-56.60			
		-20.43	-54.92		-20.37	-56.12		-20.15	-56.60			
		-20.43	-54.93		-20.35	-56.14		-20.14	-56.62			
		-20.43	-54.93		-20.35	-56.15		-20.14	-56.62			
		-20.43	-54.93		-20.28	-56.31		-20.14	-56.64			
		-20.42	-54.95		-20.27	-56.33		-20.13	-56.68			
		-20.42	-55.00		-20.24	-56.36		-20.12	-56.72			
		-20.42	-55.02					-20.12	-56.72			
		-20.43	-55.05					-20.11	-56.72			
		-20.44	-55.10					-20.11	-56.73			
		-20.44	-55.12					-20.08	-56.76			
		-20.47	-55.22					-19.98	-56.83			
		-20.51	-55.36					-19.90	-56.86			
		-20.54	-55.45					-19.89	-56.87			
		-20.55	-55.46					-19.87	-56.88			
		-20.55	-55.53					-19.84	-56.89			
		-20.55	-55.55					-19.70	-57.00			
		-20.52	-55.61					-19.55	-57.22			
		-20.50	-55.76					-19.55	-57.23			
								-19.56	-57.26			
								-19.57	-57.29			
								-19.57	-57.30			
								-19.56	-57.33			
SUMMARY												
Sampled individuals (n)	**88**			**71**			**297**			**60**		
Relative abundance (%)	**11.5**			**17.3**			**44.5**			**26.7**		
Observed richness (n)	**22**			**13**			**33**			**12**		
Chao 1 (95% CI)	**45 (26-135)**			**48 (35-94)**			**44 (37-70)**			**47 (40-75)**		

The rarefaction curves (Fig. 2) showed that richness of reptile species subjected to highway mortality tended to increase with additional records in all landscape zones, but especially in URU, ECO, and CER. Only PAN presented a slight increase in richness with the cumulative number of road-killed individuals. Bird species richness also increased with the cumulative number of road-killed individuals in PAN, as well as in ECO and URU. In the Cerrado plateau (CER), rarefaction of bird richness tended to increase greatly with additional records. The estimated richness (Chao 1) for all landscape zones reinforced these tendencies (Tables 2, 3). In CER, we estimated

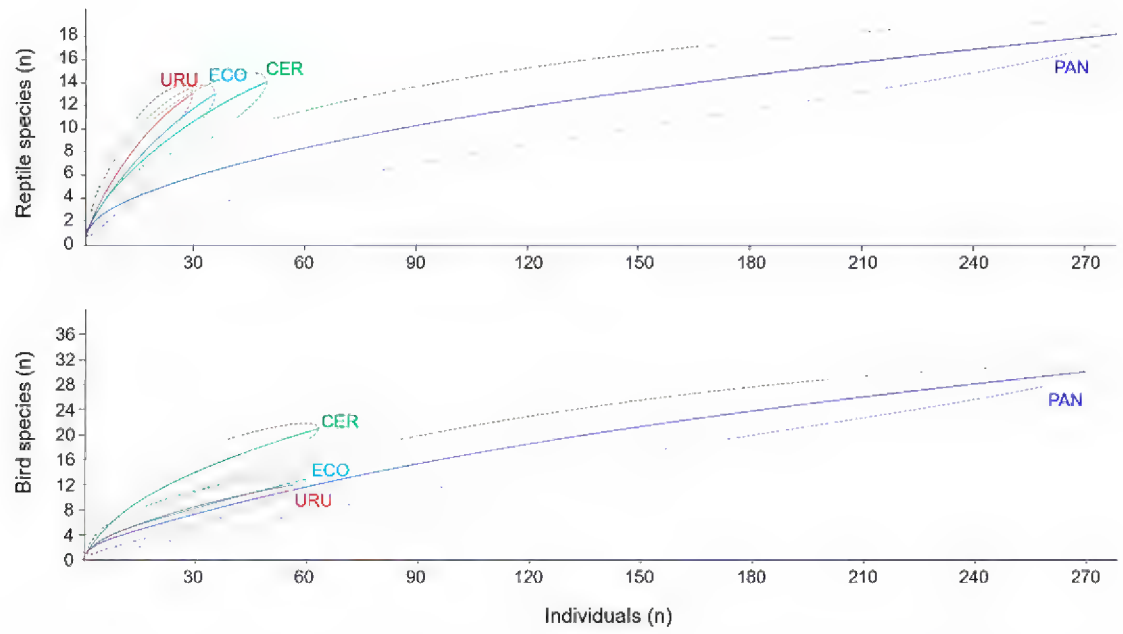

Figure 2. Cumulative curves of reptile and bird species along landscape zones crossed by the highway BR-262. CER = Cerrado plateau. ECO = Cerrado-Pantanal ecotone. PAN = Pantanal floodplain. URU = Urucum residual plateau. Dashed lines are 95% CI.

23 (16–57, 95% CI) reptile species and 45 (26–135) bird species; 25 (21–45) reptile species and 48 (35–94) bird species in ECO; 27 (23–46) reptile species and 44 (37–70) bird species in PAN; and 27 (25–45) reptile species and 47 (40–75) bird species in URU. The observed richness of reptiles in PAN corresponded to 70% of the mean richness estimated through Chao 1 index (Table 2). In CER, the observed richness of reptiles reached 65% of the expected richness; and in URU and ECO it reached 48% in both zones. For birds, the observed richness represented 75% of the expected richness in PAN, 49% in CER, 27% in ECO, and 26% in URU (Table 3.).

The most representative reptile species was the Yacare Caiman *Caiman yacare* (n = 187 individuals) followed by the Yellow Anaconda *Eunectes notaeus* (n = 83), both mainly recorded in PAN (79% and 94%). The next most representative species was the Black-and-white Tegu *Salvator merianae* (n = 44). Other representative species were *Mastigodryas bifossatus* (n = 9), *Hydrodynastes gigas* (n = 8), *Ameiva ameiva* (n = 8), *Boa constrictor* (n = 7), *Chironius quadricharinatus* (n = 6), *Bothrops* spp. (n = 6), *Dracaena paraguayensis* (n = 4), *Phrynops geoffroanus* (n = 3), *Iguana iguana* (n = 3), *Spilotes pullatus* (n = 3), *Phillodryas olfersii* (n = 6), and *Xenodon merremii* (n = 3) (Table 2). The Pantanal floodplain (PAN) showed the highest absolute abundance of reptiles (290 individuals), followed by CER (55), ECO (36), and URU (33). PAN presented the highest relative abundance (58.6% of total), followed by URU (19.8%), ECO (11.8%), and CER (9.7% of the total abundance).

The most frequently road-killed bird species were the opportunistic carnivores or scavengers *Caracara plancus* (195 individuals) and *Coragyps atratus* (116 individuals). These species were the only birds that exceeded 100 records and about 70% of their occurrences were in PAN. Other frequent occurrences were *Cariama cristata* (26 individuals, 80% of them in CER and ECO), *Crotophaga ani* (n = 15), *Guira guira* (n = 11), *Gnorimopsar chopi* (n = 10), *Paroaria capitata* (n = 5), *Eupsittula aurea* (n = 4), *Asio clamator* (n = 4), *Nothura maculosa* (n = 4), *Aramus guarauna* (n = 3), *Rhea americana* (n = 3), *Heterospizias meridionalis* (n = 3), *Cathartes aura* (n = 3), *Rupornis magnirostris* (n = 3), *Ramphastos toco* (n = 3), *Pygochelidon cyanoleuca* (n = 3), *Aramides cajaneus* (n = 2), *Aratinga nenday* (n = 2), *Bubo virginianus* (n = 2), *Rostrhamus sociabilis* (n = 2), and *Penelope superciliaris* (n = 2) (Table 3.). Like the reptiles, PAN presented higher absolute abundance of road-killed birds (297 individuals) than the CER (88), ECO (71), and URU (60). Furthermore, the highest relative abundance occurred in PAN (44.5% of total), followed by URU (26.7%), ECO (17.3%), and CER (11.5%).

Figure 3. *Hydrodynastes bicinctus* road-killed specimen collected on BR-262 highway in the Pantanal floodplain (PAN), Corumbá, Mato Grosso do Sul. First geographical record in the Brazilian Pantanal (ZUFMS-REP02721). Photograph: L Piatti.

First records. Furthermore, we recorded 1 road-killed individual of *Hydrodynastes bicinctus* on the BR-262 roadside, subregion of Miranda (19.67 °S, 057.01 °W), which is the first record of this species in the Pantanal floodplain (Fig. 3). Previously, this species has only been reported in the Cerrado plateaus and Amazon rainforest (Murta-Fonseca et al. 2015, Ferreira et al. 2017). Eight reptile species were recorded as roadkill for the first time in Brazil (new roadkill records, NRR): *Hydrodynastes bicinctus*, *Amerotyphlops brongersmianus*, *Bothrops mat-*

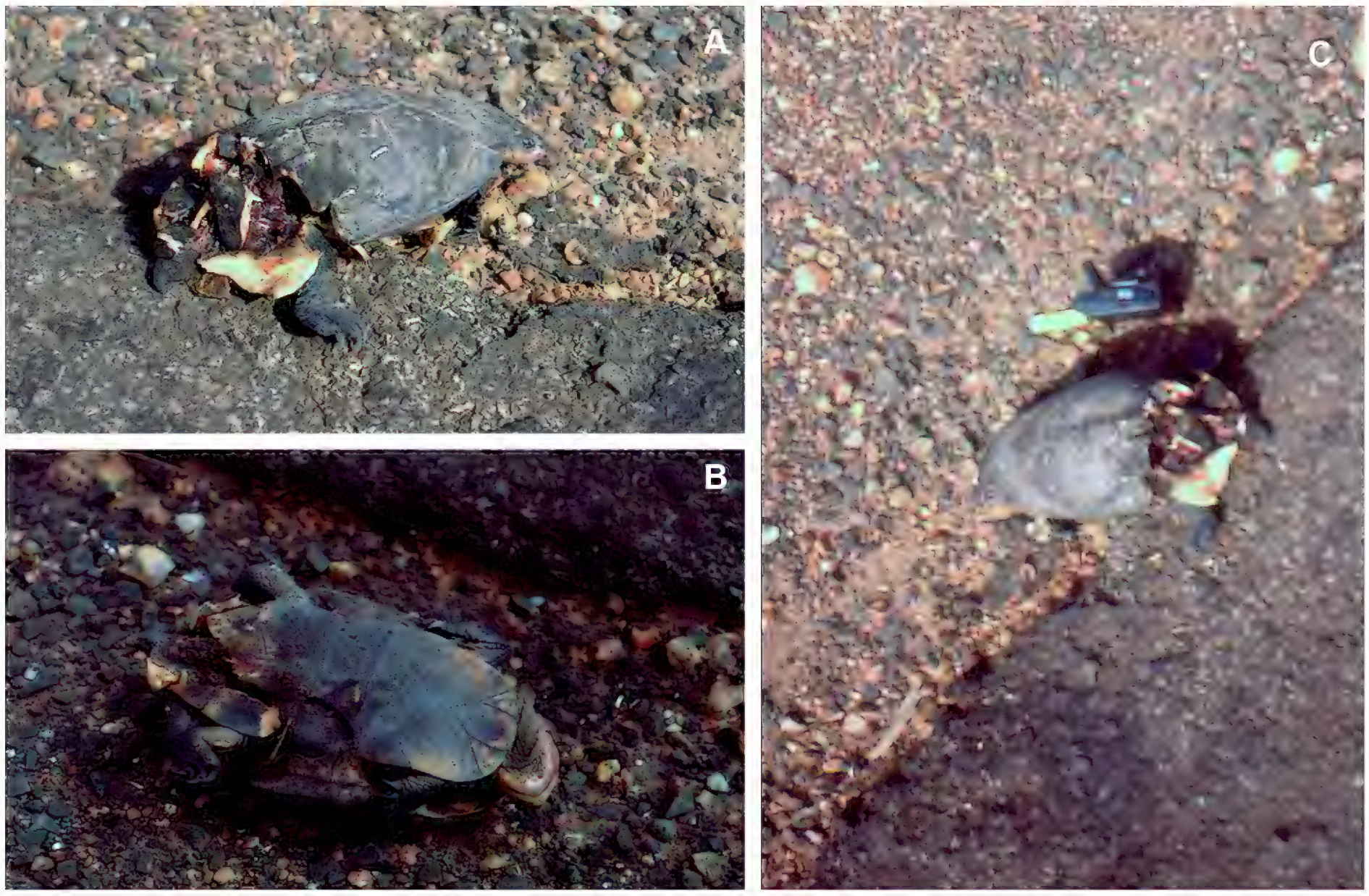

Figure 4. *Phrynops geoffroanus* road-killed individual. **A.** Dorsal view. **B.** Ventral view. **C.** Typical roadkill scenario on BR-262 with the animal's backside on the road lane and its front on the roadside. Photos: W Fischer.

togrossensis, *Eunectes notaeus*, *Helicops leopardinus*, *Mussurana bicolor*, *Dracaena paraguayensis*, and the invasive *Trachemys scripta*. For bird species, we found 12 new roadkill records (NRR): *Heterospizias meridionalis*, *Spizaetus melanoleucus*, *Urubitinga urubitinga*, *Pulsatrix perspicillata*, *Aramides cajaneus*, *Aramus guarauna*, *Jabiru mycteria*, *Jacana jacana*, *Chloroceryle americana*, *Aratinga nenday*, *Forpus xanthopterygius*, and *Icterus croconotus*.

Class Reptilia
Order Testudines
Family Chelidae

***Phrynops geoffroanus* (Schweigger, 1812)**

Records. Table 2.

Bearded Toadhead Turtles are easily recognizable, despite doubts about subspecies occurrence within the *geoffroanus* complex (Souza 2005). This freshwater chelid turtle has a typical pair of barbels with black ends (Fig. 4). This species presents broad geographical distribution in South America, and lives in all main river basins and types of habitats, including polluted urban rivers (Martins et al. 2010). Of the 3 road-killed individuals, only 2 were collectable (voucher number ZUFMS-REP02716).

Family Emydidae

***Trachemys scripta* (Schoepff, 1792)**

Record. Table 2

The Red-eared Slider Turtle is an invasive species in Brazil that is easily identified by its ~30 cm long carapace, flattened plastron, dark green head and limbs, with yellow stripes and a vivid red stripe behind the eyes, and yellow ventral parts, with green lines and spots.

Order Crocodylia
Family Alligatoridae

***Caiman yacare* (Daudin, 1801)**

Records. Table 2.

The Yacare Caiman is a large aquatic reptile with elevated eyes and nostrils on top of the head, a laterally flattened tail with a serrated crest, and transverse rows of thick plates on the back. Adults can reach lengths of 2.5–3 m (mean of total length (TL) = 138.6 ± 55.1; $n = 43$). Such features allowed us to easily identify road-killed caimans (Fig. 5). Only 2 specimens were in suitable conditions for collection (ZUFMS-REP02738 and REP02739).

Order Squamata
Suborder Lacertilia
Family Iguanidade

***Iguana iguana* (Linnaeus, 1758)**

Records. Table 2.

Common Green Iguanas were easily identified by their shape and size, and particularly by their pendulous dewlap under the throat, dorsal crest of dermal spines

Figure 5. *Caiman yacare* road-killed individuals on BR-262. **A, B.** Recently killed adult. **C–E.** Field procedures for measurements and identification. **F, G, I, J.** Road-killed adults in different decomposition processes. **H, K.** Recently killed juvenile. Photographs: R Fraga (A–E), W Fischer (F–K).

running from mid neck to the tail base, and long, tapering tail (Fig. 6). Other distinguishing features include the skull plates that are larger than others elsewhere on the body, the parietal eye that is located dorsally behind the eyes, and the subtympanic plate. We collected 2 road-killed specimens (ZUFMS-REP02732 and REP02741).

Family Teiidae

Ameiva ameiva (Linnaeus, 1758)

Records. Table 2.

Giant Ameiva individuals were recognized by their size, as well as their long tail and body color patterns,

Figure 6. A–E. Distinct conditions of road-killed *Salvator merianae* individuals (A, C, D: recently killed individuals at day light and twilight; B: testimony of the rapid action of scavengers who remove all meat and leave only skin and bones; E: living adult on the roadside). **F.** Recently killed adult *Ameiva ameiva*. **G–I.** Two distinct females of *Iguana iguana* in the reproductive season (G: female completely destroyed by vehicle, exposing its smashed oocytes on the road; H, I: another road-killed female necropsied in the laboratory, with 23 oocytes inside). **J.** Recently killed adult *Dracaena paraguayensis*. Photographs: R Fraga (B, E), W Fischer (A, C-D, F-J).

Figure 7. A–F. Several individuals of *Eunectes notaeus* crossing the BR-262 (A–D) and back roads in the Pantanal (E, F), resulting in many roadkill incidents (A). **G, H.** Young road-killed *Boa constrictor* individual. Photographs: R Fraga (B, C, F), W Fischer (A, D, E, G, H).

which consists of greenish to orange spots over a green to brown background. Adult females had longitudinal stripes on their backs and spots on their flanks (Fig. 6). We used specimens from the ZUFMS for species identification (e.g. ZUFMS-REP01329, REP01332).

Dracaena paraguayensis Amaral, 1950

Records. Table 2.

Individuals of Paraguay Caiman Lizards were only found in the Pantanal basin and were easily identified by their size (TL = 98.8 cm ± 25.7; n = 4), caiman-like tail, and enlarged dorsal scales, most of which were keeled and lined up in transverse rows (Fig. 6). Only 1 specimen was suitable for collection (ZUFMS-REP02740).

Salvator merianae (Duméril & Bibron, 1839)

Records. Table 2.

Black-and-white Tegu individuals were recognized by their size (TL = 87.0 cm ± 30.8; n = 9), scales, and skin color (Fig. 6). They had 2 divided loreal scales, smooth ventral scales, and a subcylindrical tail with caudal annuli. The head was dorsoventrally lofty with tall and divided lower labial scales. We collected four specimens (ZUFMS-REP02734, REP02743, REP02742, REP02735).

Suborder Serpentes
Family Boidae

Boa constrictor Linnaeus, 1758

Records. Table 2.

The Common Boa is the only *Boa* species. We distinguished this species by its size (TL = 143.7 cm ± 23.1; n = 6), shape, and color patterns. Specimens had large and heavy bodies, and pelvic spurs on each side of the cloacal aperture. The dorsal background was generally yellowish brown with dark bands, which were more colorful on the short tail. The triangular head had 3 distinctive dark stripes, 1 in the middle of the head from the snout to the back, and 2 larger stripes behind the eyes (Fig. 7). We collected 2 specimens (ZUFMS-REP02717, REP02722).

Eunectes murinus (Linnaeus, 1758)

Record. Table 2

The only Green Anaconda individual was very damaged by vehicles and decomposition. However, it was identified by its size (ca 6 m long), olive-green background overlaid with black blotches and circles along the body, and narrow head with yellowish orange striping on either side.

Eunectes notaeus Cope, 1862

Records. Table 2.

Yellow Anacondas are smaller than *E. murinus* and were more commonly found in the study area (n = 83). They had yellowish-green scales with dark bands and spots that overlapped and wrapped around the entire body (Fig. 7). The measurements (TL = 190.2 cm ± 59.0; n = 52) indicated a population of young individuals, that were smaller than typical adults (3–4 m long) (Norman and Naylor 1994). We collected 1 specimen (ZUFMS-REP02725), and used other specimens for identifications (e.g. ZUFMS-REP01137, REP01387).

Family Colubridae

Figure 8. A–C. Two road-killed *Spilotes pullatus* individuals (A and B-C). **D–F.** Three road-killed *Hydrodynastes gigas* individuals in different conditions. **G.** A squashed road-killed *Philodryas olfersii* individual. Photographs: W Fischer.

Chironius quadricarinatus (Boie, 1827)

Records. Table 2.

Central Sipo individuals were identified by their dorsal scale rows at midbody (12), reddish brown head and neck, bluish gray to reddish brown body, and typical rows of keeled dorsal scales. We collected 1 specimen (ZUFMS-REP02715) and used others to confirm our identifications (e.g. ZUFMS-REP01375, REP01382, REP01383, REP01656).

Drymarchon corais (Boie, 1827)

Record. Table 2

We collected 1 Indigo Snake (ZUFMS-REP00301). It was identified by its large size (TL = 202 cm), shape, and color pattern. The body had a lustrous dark-blue color dorsally and orange/yellow from midbody to the tail. The ventral side and sides of the head, chin, and throat were suffused with lustrous orange/yellow or bronze tones.

Mastigodryas bifossatus (Raddi, 1820)

Records. Table 2.

Swamp Racer snakes were identified by their size (TL = 168.8 cm ± 32.5; n = 7) and head, which is distinct from the body, large eyes, short snout, and laterally compressed body. There were apical fossils on the dorsal scales and 8 supralabials and 15 dorsal scale rows in the middle of the body. Besides the 3 specimens we collected (ZUFMS-REP00283, REP02733, REP02726), we used several specimens to help with identifications (ZUFMS-REP00249, REP00110, REP01409, REP02007, REP02009).

Spilotes pullatus (Linnaeus, 1758)

Records. Table 2.

The Yellow Rat Snake was easily identified in the field by its size (TL = 230.9 cm ± 46.9; n = 2), shape, and color pattern, and through comparisons to collected specimens (e.g. ZUFMS-REP02134). The body was slender and laterally compressed with head quite distinct from the neck. Dorsally, the body was black with yellow spots, which formed crossbands, and on the all-black tail, the yellow banding was absent. The tip of the snout was yellow. The head shields were black, with a combination of yellow and black crossbands and black sutures between shields. Ventrally, specimens were yellow, with irregular black crossbands (Fig. 8).

Family Dipsadidae

Erythrolamprus aesculapii (Linnaeus, 1758)

Records. Table 2.

The False Coral Snake was identified by its size (TL = 89.5 cm ± 6.4; n = 2) and color pattern of alternating red, black, and white rings. The arrangement of these rings showed a pair of black bands with a medial white band, the head was black with a white band posterior to the eyes, and the dorsal color patterns extended onto the belly (Fig. 9). We used collected specimens to help with identifications (e.g. ZUFMS-REP01385, REP01569, REP01629, REP01899).

Erythrolamprus poecilogyrus (Wied, 1825)

Record. Table 2

We found one Water Snake, which was identified by its shape, size (TL = 57.5 cm), and color pattern. It

Figure 9. A. Road-killed individual of *Erythrolamprus aesculapii*. **B.** An adult individual of *Thamnodynastes hypoconia* recorded in habitats around the road, similar to the road-killed specimen recorded on BR-262. Photographs: W Fischer (A), M Passos (B).

was dorsally yellowish brown and ventrally yellow. We used some collection specimens for identifications (e.g. ZUFMS-REP01527, REP01681, REP01717, REP01923, REP01941, REP01959, REP01962).

Helicops leopardinus (Schlegel, 1837)

Records. Table 2.

The Leopard Keelback individual was identified by its size (TL = 68.3 cm ± 14.5; *n* = 2), dorsoventrally flattened body, dark brown back with black spots, and yellowish white belly with black stripes and spots. We used collection specimens for comparisons (e.g. ZUFMS-REP00296, REP00931, REP01321, REP01541, REP01605, REP01715, REP01901).

Hydrodynastes bicinctus (Herrmann, 1804)

Record. Table 2

The Herrmann's Water Snake (ZUFMS-REP02721) individual was distinguished by its dorsal scales in 19/19/15 rows, lack of apical pits on the ventral and subcaudal scales, brown dorsum of the body with darker saddle-shaped blotches, black and cream-checkered ventrum, and a postocular C-shaped stripe reaching the gular region (Fig. 3).

Hydrodynastes gigas (Duméril, Bibron & Duméril, 1854)

Records. Table 2.

The False Water Cobra is a large thick-bodied snake that is easily recognized by its size (TL = 212.0 cm ± 18.0; *n* = 7), shape, and color patterns (Fig. 8). Road-killed snakes were bronze-colored with black dorsal saddles, which start as paired and fused black cross-bands and irregular rings on the first half of the body and become progressively darker and entirely black bands at the end. This species had conspicuous black stripes along the sides of the head and neck. We collected 5 specimens (ZUFMS-REP02723, REP02724, REP02729, REP02730 and REP02731).

Mussurana bicolor (Peracca, 1904)

Record. Table 2

The Two-colored Mussurana individual was identified by its size (TL = 207.5 cm) and uniformly shiny black dorsum, which becomes reddish orange laterally and whitish anteriorly on the venter; towards the tail, the venter becomes gradually grayer. The individual was completely damaged. We used other specimens to help with identification (e.g. ZUFMS-REP00257, REP01417, REP01514, REP01522, REP01555, REP01704).

Philodryas mattogrossensis Koslowsky, 1898

Records. Table 2.

Both Miranda Green Racer individuals were well preserved and vouchered (ZUFMS-REP00269, REP02728). They were identified by their shape, color, and size (TL = 137.0 cm ± 8.5; *n* = 2). These stream-lined snakes had extremely long and narrow tails. Their body dorsal colors were brown-green on the front half to orange-brown on the hind part. There were lateral stripes on the sides of the head down to the neck.

Philodryas olfersii (Lichtenstein, 1823)

Records. Table 2.

The Common Green Racer was identified by its medium-sized, slender body, long tail, relatively large eyes, all green dorsum, yellowish belly, and size (TL = 108.4 cm ± 27.0; *n* = 5). We were not able to collect any individuals (see Fig. 8). We used other specimens for identifications (e.g. ZUFMS-REP00033, REP00348, REP01428, REP01617, REP01713, REP02033, REP02112).

Thamnodynastes hypoconia (Cope, 1860)

Record. Table 2

Figure 10. An adult specimen of *Xenodon matogrossensis* captured in roadside habitats (similar to the road-killed individual recorded on BR-262). Photograph: C Santos.

The Bush Snake individual was identified by its size (TL = 42.5 cm; tail length = 23.5% of TL), cylindrical, narrow body, scale count (2 or 3 temporal, 8 supralabial, and 9 infralabial scales, with 19 rows of dorsal scales, which are imbricated and keeled in the midbody), and color pattern. This species had sepia-bronze dorsal color with black and white spots and sepia tone lines in longitudinal dorsal rows, with a yellowish dorsal line. The belly was yellowish with a dark mesh-like pattern. There was a dark stripe on the head from the eye to the corner of the mouth (Fig. 9), as verified by other specimens (e.g. ZUFMS-REP01000, REP01018 and REP02477).

***Xenodon matogrossensis* (Scrocchi & Cruz, 1993)**

Records. Table 2.

The Ringed Hognose Snake was identified by its dorsoventrally flattened body, upturned snout, 21 rows of dorsal scales at midbody, rounded tip of the tail, and color pattern. Its coral-like colors were alternated by incomplete dorsal rings, which end on the white belly. Ring colors sequence were red, black, white and black, repetitively from head to tail (Fig. 10). We used collection specimens for identifications (e.g. ZUFMS-REP00108, REP01463, REP01523, REP01620, REP01700, REP01987, REP02001, REP02145).

***Xenodon merremii* (Wagler in Spix, 1824)**

Records. Table 2.

Wagler's Snake individuals were identified by their size (TL = 112.0 cm ± 10.1; n = 3), robust body, which is flattened ventrally, and short tail (12.5% of TL). The color pattern of this species is highly variable. The dorsum had brown hourglass-shaped crossbands, which were edged with white, or the dorsum was uniformly dark black-brown. The background color was paler, from grayish brown to yellow brown, and there was a diagonal dark band bordered by a fine line from the eye to the corner of the mouth. This species is often confused with *Bothrops* spp. We vouchered all 3 road-killed specimens (ZUFMS-REP02736, REP02744, REP02737).

Family Typhlopidae

***Amerotyphlops brongersmianus* (Vanzolini, 1976)**

Record. Table 2

The Brongersma's Worm Snake was distinguished by a combination of features, including size (TL ca 33 cm), rounded dorsal and lateral head profiles, typical scale pattern, with oval rostral and preocular scales contacting the second and third supralabial scales; the eyes are small with distinct pupils. This snake is reddish brown with dark dorsal lines reaching to the black and yellowish venter. We found 1 individual that was partially smashed by vehicle traffic and identified it through comparison to museum specimens (e.g. ZUFMS-REP00197, REP00198).

Family Viperidae

***Bothrops mattogrossensis* Amaral, 1925**

Records. Table 2.

The Cerrado Lancehead was identified by its size (TL = 101.5 cm ± 20.5; n = 2) and color pattern. The supralabial scales were dark and uniformly pigmented and more conspicuous on the anterior half of the mouth. The dorsolateral blotches of the body had well-defined contours, standing out from the background color. The postocular stripes were well defined. The keels always had the same coloration as the dorsal scales. There were blotches in the interspaces between 2 consecutive blotches. We used several specimens for identifications (e.g. ZUFMS-REP00005, REP00058, REP00286, REP00342, REP01333, REP01530, REP01726, REP01869, REP02137).

***Bothrops moojeni* Hoge, 1966**

Records. Table 2.

The Brazilian Lancehead was identified by size (TL = 89.5 cm ± 6.0; n = 4) and grayish brown background color, with a series of dark hourglass-shaped bands that are narrowest dorsally with paler centers and borders, the top of the head matched the background color, and the face was pale with a post ocular stripe. We vouchered all 4 specimens found (ZUFMS-REP01864, REP02720, REP02718, REP02719).

***Crotalus durissus* (Laurenti, 1768)**

Record. Table 2

The single vouchered Rattlesnake (ZUFMS-REP02727) specimen was identified by its size (TL = 117.0 cm) and heavy, thick and somewhat triangular body,

Figure 11. A. Usual behavior of *Jabiru mycteria* in Pantanal area (landed and resting on the road banks or roadsides). **E, F.** A road-killed adult individual of *J. mycteria* on the BR-262 (at twilight). **B, C.** Two living individuals of *Rhea americana* crossing BR-262 lanes in the URU landscape zone as usual. **D.** A road-killed individual of *Ramphastos toco* on the roadside. Photographs: W Fischer.

which was covered with large, strongly keeled scales. It was easily recognized by the rattle at the end of the tail.

Class Aves
Order Struthioniformes
Family Rheidae

***Rhea americana* (Linnaeus, 1758)**

Records. Table 3.

The Greater Rhea is the largest flightless bird species in Brazil (Fig. 11), and is easily recognized by its size (TL ca 1.5 m), long neck and legs, no tail, and brown-gray plumage. The males have a black breast and neck.

Order Tinamiformes
Family Tinamidae

***Crypturellus parvirostris* (Wagler, 1827)**

Record. Table 3.

The Small-billed Tinamou was recognized by its size (almost 20.0 cm long), ratite-like shape (small wingspan; no tail), dark brown upperparts, grey to brownish underparts and head, and red bill and legs.

***Nothura maculosa* (Temminck, 1815)**

Records. Table 3.

Spotted Nothura individuals were recognized by their size (ca 25 cm long), ratite-like shape, brown upper parts with beige streaks, under parts with beige-streaks, black and brown on the breast, barring on the flanks, a black crown with beige streaks, white throat, and dull yellowish-brown legs.

***Rhynchotus rufescens* (Temminck, 1815)**

Record. Table 3.

The Red-winged Tinamou was recognized by its relatively large size (ca. 40 cm long), ratite-like shape, black crown, rufous primary feathers, and light gray underneath. This species has black bars on the flanks, abdomen and vent, a whitish throat, a bronze fore-neck and breast, and dark patch behind the eyes.

Order Galliformes
Family Cracidae

***Penelope superciliaris* Temminck, 1815**

Records. Table 3.

The Rusty-margined Guan was easily identified by its large size (> 50 cm long), its naked red barbel and rudimentary tuft, wing plumage with rusty edges, a whitish design on the chest, and light grayish brown eyebrows.

Order Ciconiiformes
Family Ciconiidae

***Jabiru mycteria* (Lichtenstein, 1819)**

Record. Table 3.

The Jabiru was easily recognized, as it is the tallest flying bird in Brazil and South America. The single adult Jabiru measured 127 cm long and the broad, black beak, with slightly upturned, sharply pointed at the end and was 32 cm long; the tarsus measured 31 cm long, and the wing chord (Wc) = 64 cm. The plumage was mostly white, the head and upper neck were black and featherless, and there was a featherless red stretchable pouch at the base of the neck (Fig. 11).

Figure 12. A, B. Two road-killed individuals of *Cariama cristata*. **C.** A usual scenario on BR-262, vultures like *Coragyps atratus* landed near roads, waiting for the next animal-vehicle collision. **D, F, H.** Records of double animal roadkill, representing typical situations on BR-262; roadkill of *Cariama cristata* and *C. atratus* at the same time (D); a road-killed animal on the roadside (behind the vehicle) and another road-killed *C. atratus* on road lanes (H). **E–G.** Similar incidents recorded for *Cathartes aura*. Photographs: W Fischer.

Order Cathartiformes
Family Cathartidae

***Cathartes aura* (Linnaeus, 1758)**

Records. Table 3.

Turkey vulture individuals were identified by size, shape, and color pattern (Fig. 12). The body feathers were mostly brownish-black, but the flight feathers on the wings were silvery-gray underneath, contrasting with the darker wing linings. The head was small in proportion to the body and red in color with no feathers. This species also has a relatively short, hooked, ivory-colored beak. Its legs and feet are pink-skinned with white marks.

***Cathartes burrovianus* Cassin, 1845**

Record. Table 3.

The Lesser Yellow-headed Vulture was identified by its brownish-black plumage. The head, neck and throat were featherless with yellow skin, reddish forehead, and gray-blue nape and crown. The flesh-colored beak was thick and hooked at the tip. This species has a rounded and short tail and white legs, with long front toes with small webs.

***Coragyps atratus* (Bechstein, 1793)**

Records. Table 3.

Black Vulture individuals (n = 116) were easily identified by size (mean of wing chord (Wc) = 46.0 cm ± 5.1, n = 20), the short, broad wings, short and squared tail, which barely reaches past the edge of the folded wings, and color. The plumage was glossy black. The bases of the primary feathers were white, producing a white patch on the underside of each wing's edge. The head and neck were featherless, and the skin was dark gray and wrinkled. The legs were grayish white, the tarsus long, and the flat feet had 2 long front toes with small webs at their bases (Fig. 12).

Figure 13. A–E. *Caracara plancus* individuals. **A.** In small flocks at BR-262 roadside vegetation, waiting for the next road-kill event. **D, E.** Solitary individuals on the ground, defending roadside territories against competitors, including conspecific individuals. **C-D.** Road-killed and living individuals with adult color plumage. **B, E.** Road-killed and living individuals with primary color plumage (young adults). **F.** Road-killed individual of *Falco sparverius*. **G.** Road-killed individual of *Heterospizias meridionalis*. Photographs: R Fraga (A, D-E), W Fischer (B-C, F-G)

Order Accipitriformes
Family Accipitridae

***Heterospizias meridionalis* Latham, 1790**

Records. Table 3.

Savanna Hawk individuals were identified by their size (Wc = 40.7 cm ± 1.4; $n = 3$), shape, and color pattern. The individuals had a rufous body with grey mottling above and fine black barring below. The flight feathers of the long broad wings were black, and the tail was banded black and white; the legs were yellow (Fig. 13).

***Rostrhamus sociabilis* (Vieillot, 1817)**

Records. Table 3.

Snail Kite individuals were identified by their size (Wc = 31.0 cm ± 2.8; $n = 2$), shape, and color pattern. They had long, broad, rounded wings, long tail with a white rump and under tail coverts, a dark and deeply hooked beak, and a long tarsus. Both of the road-killed individuals had dark brown upperparts and heavily streaked, pale underparts; they had a whitish face with darker areas behind and above the eye, and the legs were yellow. The 2 individuals were probably both adult females.

***Rupornis magnirostris* (Gmelin, 1788)**

Records. Table 3.

The Roadside Hawk was identified by its size (ca 40 cm long), shape, and color pattern. The individual was mainly brownish grey with a touch of rufous on the wings. The lower breast and underparts were barred brown and white, and the tail had grey bars. As the common name suggests, we frequently observed these hawks foraging on BR-262 roadsides.

***Spizaetus melanoleucus* (Vieillot, 1816)**

Record. Table 3.

The road-killed Black-and-white Hawk-Eagle individual was identified by its shape, size (Wc = 35.7 cm; probably an adult male), and color. The carcass was in poor condition, and was flattened and separated in parts by scavengers. However, we identified it by its white plumage on the underparts, white head and neck with black

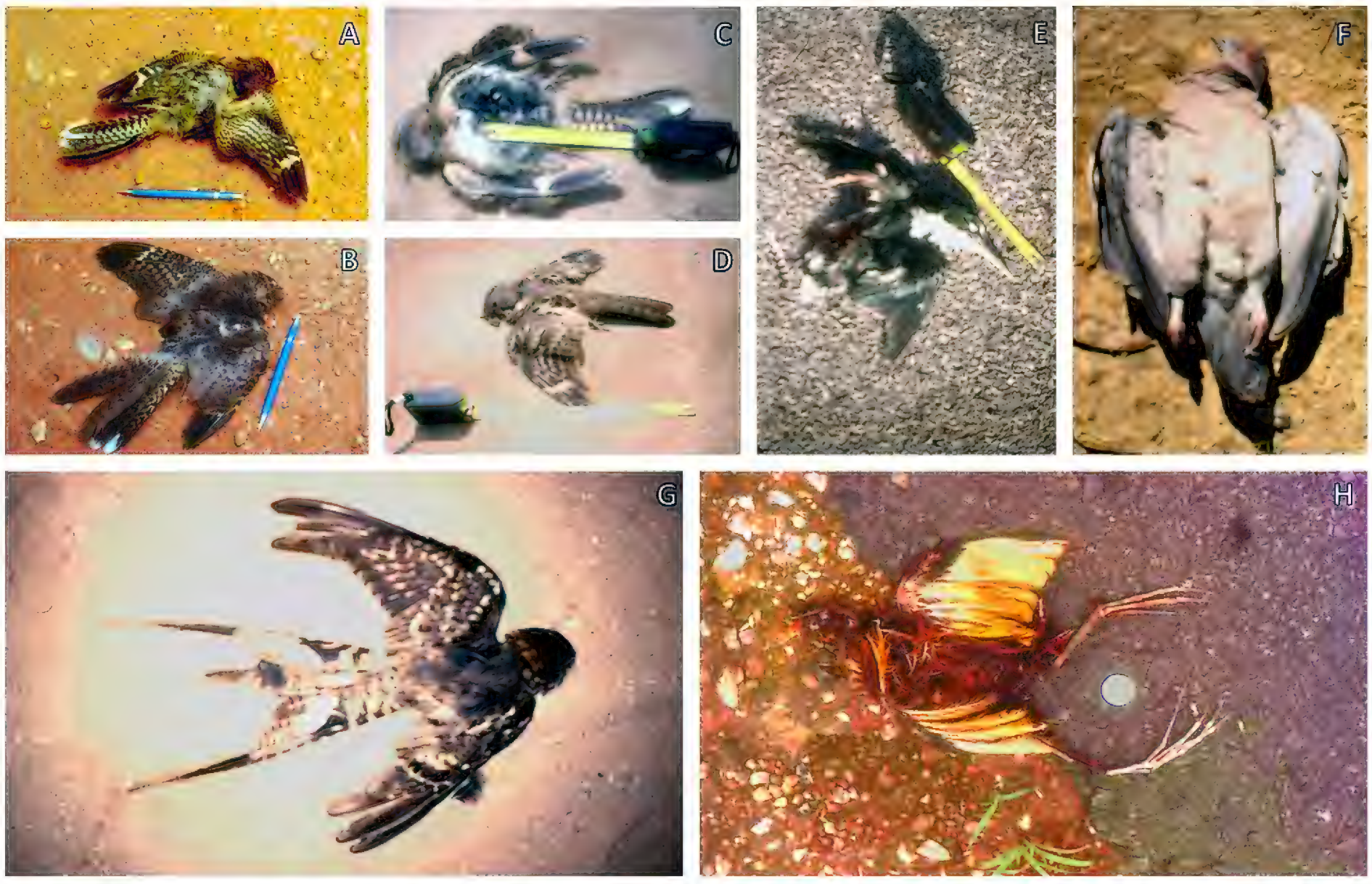

Figure 14. A–D. Road-killed individuals of *Nyctidromus albicollis* (ventral and dorsal views, respectively). **E.** Road-killed individual of *Chloroceryle americana*. **F.** Road-killed individual of *Patagioenas picazuro*. **G.** Road-killed individual of *Hydropsalis torquata* (dorsal view). **H.** Road-killed individual of *Jacana jacana* (very damaged but still recognizable). Photos: W Fischer.

mask and crest, orange cere and beak with black tip, black upper wings and shoulders; the feathers of the tail were barred black with white tips, the yellow feet had black talons, and the tarsi were completely white-feathered.

Urubitinga urubitinga (Gmelin, 1788)

Record. Table 3.

The Great Black Hawk was identified by its black body plumage and wings, yellow cere and bill with black tip, thigh and flight feathers with white bars, white and short tail with a broad black tip, and yellow legs.

Order Falconiformes
Family Falconidae

Caracara plancus (Miller, 1777)

Records. Table 3.

Southern Caracara (n = 196) individuals were easily recognizable by their size (Wc = 38.3 cm ± 3.2; n = 50), shape, and color. Adult individuals had dark brownish cap, belly, thighs, most of the wings, and tail-tip. The auriculars, throat, and nape were whitish beige; the chest, neck, mantle, back, uppertail and undertail coverts, and basal part of the tail were whitish beige barred with dark brown. The bare facial skin and cere were deep-yellow to reddish-orange; the legs were yellow. The juveniles resembled adults in color but were paler, with streaking on the chest, neck, and back, the facial skin and cere were pinkish, and their legs were grey (Fig. 13).

Falco sparverius Linnaeus, 1758

Record. Table 3..

American Kestrel was recognized by the small size (Wc = 17.5 cm), shape, and color (Fig. 13). The road-killed individual had a dark reddish-brown back and wings with fine black barring. The posterior underparts were rufous, with light orange brown tones having vertical black scratches. The tail was rufous with narrow dark bars. The top of the head was dark gray with a black spot on the nape. There was a black teardrop-like spot below the eyes and a vertical white line on each side of the head.

Order Gruiformes
Family Aramidae

Aramus guarauna (Linnaeus, 1766)

Records. Table 3..

Limpkin individuals are very common in the Pantanal and is a well known, large aquatic bird species (Wc = 43.7 cm ± 0.8; n = 3). The plumage color is drab, dark brown with an olive luster on top; the feathers of the head, neck, wing coverts, back, and underside (except the rear) are streaked with white. The long and down-curved bill is yellowish, with a darker tip. The legs are long and dark.

Family Rallidae

Aramides cajaneus (Statius Müller, 1776)

Records. Table 3.

The road-killed Grey-necked Wood-rail individuals were identified by size (Wc = 18.8 cm ± 0.4; *n* = 2), shape, and color pattern. The upperparts were greenish dark-brown, the head and neck were grey, blending into a brown patch at the back of the head; the periocular ring was red; the bill was yellow with a greenish pit. The chest and flanks were rufous; the belly, rump and tail were black. The legs were red.

Order Cariamiformes
Family Cariamidae

***Cariama cristata* (Linnaeus, 1766)**

Records. Table 3.

The road-killed Red-legged Seriema individuals were unmistakable when seen on road lanes or roadsides (Fig. 12). These large terrestrial birds (Wc = 36.0 cm ± 1.1; *n* = 6) were very distinct due to several features, including the long and bright-red legs and brushy crest extending from the base of the upper red bill. Their body feathers were gray with shades of brown, and white on the abdomen; around the neck and underparts the plumage was loose; skin surrounding the eyes was blue; eyelash-like feathers around their eyes; wing and tail feathers with black and white bands.

Order Charadriiformes
Family Jacanidae

***Jacana jacana* (Linnaeus, 1766)**

Record. Table 3.

The Wattled Jacana is another conspicuous and unmistakable bird species. The road-killed individual was very damaged (Fig. 14), but still recognizable as *J. jacana* by its size, shape, and typical colors. The individual was dark brown on the back and wing coverts; remiges were yellow but the rest of the body was mainly black. The bill was yellow and a red coot-like head shield and a reddish wattle was present. The legs were bluish gray, with long toes. There were sharp spurs on the wing bends.

Order Columbiformes
Family Columbidae

***Patagioenas picazuro* (Temminck, 1813)**

Record. Table 3.

The Picazuro Pigeon was identified by its color, shape, and size (Fig. 14); this species is the largest columbid in Brazil. The individual was dark bluish gray on the flanks and tail coverts, its breast, head, neck, and nape were bluish purple, with the nape with white dashes, and the wings were dark gray with white bands.

***Zenaida auriculata* (Des Murs, 1847)**

Record. Table 3.

The road-killed Eared Dove individual was identified by size (ca 25.0 cm long) and the 2 small black stripes behind the eyes, which forms an ear-like design. It has dull greyish-brown plumage with pale barring, black spots on the wings, and a long wedge-shaped tail. The bill is black and the legs are dark red.

Order Psittaciformes
Family Psittacidae

***Aratinga nenday* (Vieillot, 1823)**

Records. Table 3.

The Nanday Parakeet is an unmistakable species. Both road-killed individuals were about 35.0 cm long with predominantly green plumage. Their most characteristic feature was the black facial mask and beak. The chest was bluish-green with paler green lower parts. The trailing flight feathers on the wings were black, the long tail was edged in blue, and the tibial feathers were red.

***Eupsittula aurea* (Gmelin, 1788)**

Records. Table 3.

The Peach-fronted Parakeet individuals were quickly distinguished by size (ca 27.0 cm long), shape, and color. They had green plumage, yellowish on the belly, and bluish on the face, with the typical peach-coloured cap and yellow ring around the eyes.

***Forpus xanthopterygius* (Spix, 1824)**

Record. Table 3.

The Blue-winged Parrotlet is the smallest parrot species in Brazil. It was recognized by its small size (ca 12 cm long), shape, color, which is mainly green and short, tapered tail. The species is sexually dimorphic, and our road-killed individual was an adult male since it had blue feathers on the bend of the wing, underwing-coverts, blue lower back, and rump. The females are completely green.

Order Cuculiformes
Family Cuculidae

***Crotophaga ani* Linnaeus, 1758**

Records. Table 3.

The Smooth-billed Ani individuals were distinguished by their size (Wc = 34.5 cm ± 0.7; *n* = 6), flat black, long tail, and deeply ridged black bill.

***Guira guira* (Gmelin, 1788)**

Records. Table 3.

Guira Cuckoo individuals were identified by size (Wc = 37.8 cm ± 1.8; *n* = 4), whitish-buff underparts and rump, dark brownish upperparts, long white-tipped dark tail, orange-rufous crest, bare yellow ocular-skin, and orange-yellow bill.

Order Strigiformes
Family Strigidae

***Asio clamator* (Vieillot, 1808)**

Records. Table 3.

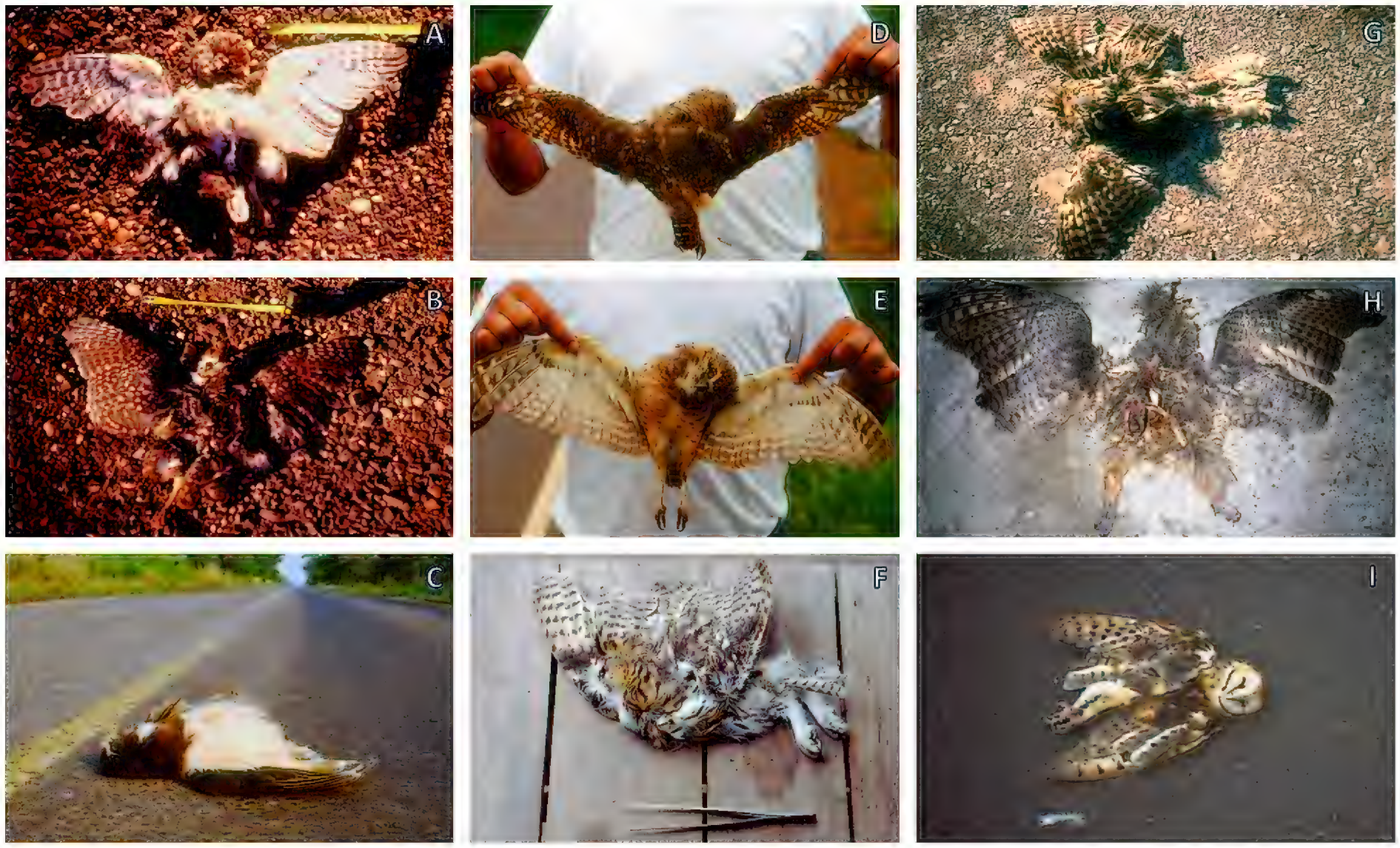

Figure 15. A, B. Road-killed individual of *Glaucidium brasilianum* (ventral and dorsal views, respectively). **C.** Road-killed individual of *Pulsatrix perspicillata* (ventral view). **D, E.** Road-killed individual of *Athene cunicularia* (dorsal and ventral views, respectively). **F.** Road-killed individual of *Asio clamator* (dorsal view). **G, H.** Road-killed individuals of *Bubo virginianus* (dorsal views only). **I.** Road-killed individual of *Tyto furcata* (ventral view). Photographs: W Fischer.

Striped Owl individuals were identified by size (Wc = 26.0 cm ± 6.1; n = 3), shape, and color pattern (Fig. 15). Upperparts were beige streaked with black, white, and gray. A long tuft of blackish brown and whitish beige feathers over each eye looked like "ears". The bill was dark, short, and hooked. The remiges were beige, with broad, dusky brown transverse bars; the rectrices were whitish, barred with dusky brown. The throat was white, and the underparts beige, streaked with dark brown and black. The tarsi and toes were feathered and whitish, but with dark claws.

Athene cunicularia (Molina, 1782)

Records. Table 3.

Burrowing Owls are a small-bodied species (Wc = 18.0 cm) and individuals had round heads, lacked ear tufts, and had relatively long legs (Fig. 15). The plumage was sandy brown on the upperparts with whitish spots on the body, while the face was adorned with bold whitish eyebrows and a prominent white chin stripe; the underparts were buff-white with brown barring.

Bubo virginianus (Gmelin, 1788)

Records. Table 3.

The Great Horned Owl is a large species recognized by its typical horn-like ear tufts. The road-killed individuals were identified by their size (Wc = 38.1 cm ± 0.7; n = 2), shape, and color pattern (Fig. 15). They had a distinctive whitish bib-like throat patch, large eyes, and powerful and fully feathered talons. Plumage was white to buff, suffused with darker shades of black-brown; the underside was buff with beige and dark brown barring and dark brown tips on the feathers. The tail was short and barred with white edges.

Glaucidium brasilianum (Gmelin, 1788)

Records. Table 3.

Ferruginous Pygmy-owls were distinguished by size (Wc = 19.8 cm ± 0.4; n = 2), shape, and color pattern (Fig. 15). The upperparts were drab brown; there were whitish spots on the scapulars and wing coverts, narrow longitudinal buff streaks on crown and nape, a broken white collar across the nape (white throat), a brown tail with transverse whitish bars, and a white belly broadly streaked with brown.

Pulsatrix perspicillata (Latham, 1790)

Record. Table 3.

The Spectacled Owl individual was easily identified by size (Wc = 32.5 cm), shape, and color (Fig. 15). It had blackish brown upperparts, including head and upper breast, white eyebrows and facial markings, a pale beak, and yellowish-ochre underparts, with a brown, collar-like chest band which was broken up by buffy-whitish barring.

Family Tytonidae

Tyto furcata (Temminck, 1827)

Record. Table 3.

The American Barn Owl was easily distinguished by its size (ca 40 cm long), triangular facial disk with a heart-shaped face, and tan head and body, with creamy white underparts on the breast, and cinnamon colored upperparts (Fig. 15).

Order Caprimulgiformes
Family Caprimulgidae

***Hydropsalis torquata* (Gmelin, 1789)**

Record. Table 3.

The Scissor-tailed Nightjar had a short bill with a broad gape, and short tarsi. This species is cryptically colored with grayish brown plumage, and has a tawny collar across the nape. The typical feature that identifies the species is the elongated outer rectrices (the scissor) with white on the inner webs, which confirmed our individual was a male (Fig. 14). The wings were uniformly dark with no white band across the outer primaries.

***Nyctidromus albicollis* (Gmelin, 1789)**

Records. Table 3.

Common Pauraque individuals were identified by size (mean Wc = 15.3 cm ± 1.8), shape, and color pattern (Fig. 14). They had very long tails with white bands on the rectrices and across the wings, well-defined ear patches, and lacked a nuchal collar. Both specimens presented female patterning, with a brood patch on the abdomen in the larger specimen.

Order Coraciiformes
Family Alcedinidae

***Chloroceryle americana* (Gmelin, 1788)**

Record. Table 3.

The road-killed Green Kingfisher individual was a female and presented a brood patch on the underside (Fig. 14). It was identified by size (Wc = 14.0), short tail, long bill, and coloration. The upperparts were oily green above with white markings on the wings and tail; there was a white collar around the neck; the white underparts had 2 green chest bands, with the lower band linking to the green spots along the sides of the belly.

Order Piciformes
Family Ramphastidae

***Ramphastos toco* Statius Müller, 1776**

Records. Table 3.

The road-killed Toco Toucan individuals were easily recognized by their size (WC = ca 23 cm), shape, and color pattern (Fig. 11). The bill was very large and reddish orange with a black spot at the tip of the maxilla. There was bright orange orbital skin with a narrow blue ring around the eyes. The plumage was mostly glossy black, but the throat and upper breast and upper tail coverts were red.

Family Picidae

***Colaptes campestris* (Vieillot, 1818)**

Records. Table 3.

The Campo Flicker was easily distinguished by its shape and color. The sides of the head, neck, and breast were bright yellow. Around the eyes, the feathers were dull white. The crown was black, and the back was dark, barred with white, and the rump was white, with a few thin bars. The underwing feathers were yellowish-white.

Order Passeriformes

Passeriformes presented the highest number of unidentified road-killed individuals, since approximately 30% were in good enough condition to be identified to species. This large group includes small, inconspicuous birds, many of which are sexually dimorphic. After collisions with vehicles, their carcasses remained on the roads for very short periods of time before being consumed by scavengers or being completely destroyed. Below we present the specimens we were able to identify.

Family Emberizidae

***Paroaria capitata* (d'Orbigny & Lafresnaye, 1837)**

Records. Table 3.

The road-killed Yellow-billed Cardinal individuals were mostly recognized by their color patterns, which consisted of a bright red head with rounded crown, yellow bill (the same color as the legs), black bib, white partial nuchal collar, black upperparts, and snowy white underparts.

Family Furnariidae

***Furnarius rufus* (Gmelin, 1788)**

Record. Table 3.

The Rufous Hornero individual was identified by its medium-sized body, square tail, and slightly decurved bill, as well as by its rufescent brown upperparts, light rufous supercilia, whitish throat, and tawny breast and underparts.

Family Hirundinidae

***Pygochelidon cyanoleuca* (Vieillot, 1817)**

Records. Table 3.

Blue-and-white Swallow individuals were identified by their short and relatively broad wings, short and slightly forked tail, glossy steel-blue upperparts, blackish wings and tail with steel-blue margins, and white and light gray undersides and flanks.

Family Icteridae

***Gnorimopsar chopi* (Vieillot, 1819)**

Records. Table 3.

Chopi Blackbirds individuals were easily recognized by their size (Wc = 12.8 cm ± 0.4; n = 3), shape, and all-black color. Besides the black plumage on the entire body, they had very slightly curved bills with a groove along the lower mandible.

***Icterus croconotus* (Wagler, 1829)**

Record. Table 3.

The Orange-backed Troupial individual was easily recognized by its bright orange body and black face, bib, wings, and tail. The specimen had a small white patch on the secondary wing feathers, an orange streak on its shoulder, and a small blue ring around both eyes.

Family Turdidae

***Turdus amaurochalinus* Cabanis, 1850**

Record. Table 3.

The road-killed Creamy-bellied Thrush individual was distinguished by its brownish plumage, which was olive-brown above, brown-streaked white throat, and creamy white belly, and by the yellowish bill, and black lores.

***Turdus rufiventris* Vieillot, 1818**

Record. Table 3.

The Rufous-bellied Thrush individual was well recognized by its size (ca 25 cm long) and by its olive-brown upperparts, a buff-brown breast, orange belly, and orange-yellow eye rings.

Family Tyrannidae

***Pitangus sulphuratus* (Linnaeus, 1766)**

Record. Table 3.

The Great Kiskadee is a well-known bird, which made its identification easy. It had a short, thick, black bill, a black crown with yellow coronal stripe, and broad white supercilium that extended from forehead to nape. The upperparts were olive-brown, and wings and tail had strong rufous fringes.

***Tyrannus savana* Daudin, 1802**

Records. Table 3.

The road-killed Fork-tailed Flycatcher individuals were identified by their dark upperparts and white underparts, and by their black color on the head, wings and tail, with gray on back. They are especially distinct because of their long and bifurcated tail with elongated outer rectrices that are basally edged white, which are oftentimes longer than the body, and even longer in males.

Discussion

First records. Based on the most recent reptile checklist from Mato Grosso do Sul (Ferreira et al. 2017), which encompasses a broad inventory of the Pantanal and surrounding plateaus, our record of *Hydrodynastes bicinctus* (Dipsadidae) in the Pantanal basin is the first geographic record (FGR) for this species (Table 2). *Hydrodynastes bicinctus* has only been reported in open areas of the Cerrado plateaus and Amazon rainforest (Murta-Fonseca et al. 2015). In Mato Grosso do Sul, *H. bicinctus* was only reported in the municipalities of Bataguassu, Ivinhema, Paraíso das Águas, Três Lagoas, and Santa Rita do Pardo (Murta-Fonseca et al. 2015), while the reptile checklist from the state (Ferreira et al. 2017), which included areas near the BR-262 between Campo Grande and Corumbá, did not make any record of this species.

We found new roadkill records for both reptiles and birds in Brazil. Furthermore, it is notable that 83 *Eunectes notaeus* and 4 *Dracaena paraguayensis* were road-killed at reproductive ages (Table 2); such mortality could negatively impact their population sizes. For bird species, the most recent checklist does not classify species occurrences by macroregions in Mato Grosso do Sul (Nunes et al. 2017), so we found no first geographical records, but we did record 12 new species of road-killed birds in Brazil. Large aquatic birds like *Jabiru mycteria* and *Aramus guarauna,* as well as small ones like *Aramides cajaneus, Jacana jacana,* and *Chloroceryle americana* are quite unusual road-killed species. The roadkill record of a *Spizaetus melanoleucus* is also concerning, as it is a species that is vulnerable to extinction in the Atlantic Forest (Menq 2016). Our record of *S. melanoleucus* in the Pantanal floodplain (Table 3.) was approximately 15 km from the westernmost remnant of Atlantic Forest in the Serra da Bodoquena (Ribeiro et al. 2009), which is the closest area from where this species was previously reported (Pivatto et al. 2006).

Richness and abundance. The 29 species of reptiles identified here represent 15% of reptile richness (188 species), and the 47 species of birds represent 7% of the avifauna (630 species) previously reported for Mato Grosso do Sul (Ferreira et al. 2017, Nunes et al. 2017). The richness estimated for road-killed reptiles supports a more complete sample in PAN and CER than in the transitional landscapes of the ECO and URU, where it is likely that several other road-killed species were not recorded. A similar situation seemed to occur for bird richness, which was estimated more completely in the PAN landscape zone. In CER, and especially in ECO and URU, richness of road-killed birds seemed to be higher than those recorded here. De Souza et al. (2014) surveyed road-killed species in 2 landscape zones (215 km) that we investigated herein, ECO and PAN. They found 7 reptiles and 12 bird species, with most of them recurrent on our list (79%). However, they recorded 4 bird species—*Amazona aestiva, Buteo magnirostris, Ceryle torquata,* and *Tyrannus melancholicus*—that we did not encounter. Thus, the spectrum of animals affected by vehicle collisions on the BR-262 highway is larger than we were able to measure during the surveyed years.

The patterns of abundance for road-killed fauna were coherent with the expectations for the Cerrado and Pan-

tanal landscapes (Fischer 1997, Casella 2010, De Souza et al. 2014). The most abundant road-killed species were those that use the environments provided by the creation of the road, such as roadside vegetation and marginal water ponds (Fischer 1997). Assuming that detection and removal rates did not vary among zones, the high number of reptiles and birds in PAN and URU zones would confirm the high abundance and richness of both groups in the Pantanal basin (De Souza et al. 2014, Ferreira et al. 2017, Nunes et al. 2017). On the other hand, the low relative abundance of individuals in CER and ECO could be related to the environmental features in these regions, which are less preserved than the Pantanal floodplain region (Casella 2010). Most individuals in the Cerrado zone are likely road-killed when crossing the BR-262 during movements between foraging areas, whereas individuals in the Pantanal zone use roadside environments as refuges or for feeding (Fischer 1997, Catella et al. 2010, De Souza et al. 2014).

Roadkill data is biased for large individuals because their carcasses stay on the road for longer amounts of time before being carried away by carnivores or scavengers, or until their bodies decay (Fischer 1997). Reptiles are attracted to paved roads for thermoregulation, especially in the evening, because road lanes store heat for longer periods than other substrates (Silva et al. 2007, De Souza et al. 2014) and because of their scavenging behavior (e.g. *Hydrodynastes gigas*) (Ucha and Santos 2017). Snakes and other animals that humans instinctively fear (e.g. caimans) may be intentionally killed on roads (Secco et al. 2014), independent from their high abundance around the road. For aquatic reptiles, such as caimans and water snakes (e.g. *Eunectes notaeus, Hydrodynastes* spp., *Helicops leopardinus*, and *Erythrolamprus poecilogyrus*), the marginal water ponds on both sides of the road banks in the Pantanal zone promote intense and unsafe animal crossings over the lanes (Fischer 1997, De Souza et al. 2014). In fact, life history traits like diet, may explain the high roadkill frequency of fruit- or seed-eating birds (e.g. *Ramphastos toco, Aratinga nenday, Eupsittula aurea, Crotophaga ani, Guira guira, Paroaria capitata*, and *Gnorimopsar chopi*) (Cook and Blumstein 2013), which are frequently attracted to fruit or seed sources available along the roadsides of the BR-262.

The abundance of 2 birds, *Caracara plancus* and *Coragyps atratus* (n = 195 and n = 116, respectively), road-killed on the BR-262 is remarkable. They are attracted to roads and roadsides by other roadkill and are then killed by vehicle collisions (Figs 12, 13). Roadways are a predictable food source for scavengers, including snakes, which can bias estimates of road-killed vertebrates. For snakes, scavenging behavior may also be the cause of their mortality on roads (Ucha and Santos 2017). Other recorded vultures, falcons, hawks and owls are also road-killed because of the same opportunistic behavior on roadsides (e.g. *Cathartes aura, C. burrovianus, Heterospizias meridionalis, Rupornis magnirostris, Spizaetus melanoleucus, Urubitinga urubitinga, Asio clamator, Athene cunicularia, Bubo virginianus, Glaucidium brasilianum, Pulsatrix perspicillata, Tyto furcata* and *Nyctidromus albicollis*). Some of these species forage at night when roadkill risks increase significantly (Bencke and Bencke 1999, M. Gordo pers. comm. 2003). Top predators, such as accipitrids, falconids, strigids and cathartids, including *Spizaetus melanoleucus*, are agile, sagacious, and rare victims of road kill (Menq 2016), which makes these records even more impressive.

The terrestrial habit of *Cariama cristata* seems to be fatal around highways (Fig. 12). Once on the roads, this species typically runs (up to 25 km/h) to escape from a vehicle before starting to fly (Redford and Peters 1986). Similarly, *Rhea americana, Nothura maculosa, Crypturellus parvirostris, Rhynchotus rufescens*, and *Penelope superciliaris* are also vulnerable to road traffic (Fig. 11). In the Pantanal zone, aquatic birds such as *Aramus guarauna, Aramides cajaneus, Jabiru mycteria, Jacana jacana*, and *Chloroceryle americana,* face increased risks when feeding on artificial ponds along roadsides (Cook and Blumstein 2013).

In general, our results reinforce concerns about wildlife roadkill on the BR-262 highway, especially near the Pantanal where roadkill frequency seemed to be greater than in the Cerrado zone. Moreover, the expected richness of reptiles and birds involved in vehicle collisions on the BR-262 is much higher than we observed. Thus, mitigation of wildlife-vehicle collisions on this road is still urgent for biodiversity conservation and for human and animal safety and care. Furthermore, animal overpasses and underpasses with roadside fences should be considered along landscape hotspots, as well as the less effective safety methods as signs and traffic speed control (e.g. Fischer 1997, GEIPOT 1999, Catella et al. 2010). The main goal for wildlife management programs around roads is to determine the target species of greatest concern, focusing on species vulnerable to local extinction or the ones that represent major risks of serious accidents, and especially on species that inhabit roadside environments and are prone to crossing the road.

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Authors' Contributions

WF collected field data, participated in all manuscript processes, including species identification and data analysis, and writing of the text. RFG participated in data analysis, including geospatial treatments, and the writing process as a co-author. ACPF supervised all processes and especially contributed to geospatial data analysis and the writing process as a co-author.

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